Attorney Docket
No. 2909

#9

6-4-03

IN THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re:	Serial No. 09/667,981	)
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		)
		)
Filed:	September 22, 2000	) Examiner: Huang, Shong
		)
Inventors:	George Burnett	) Art Unit: 2632
	Joshua K. Brown	)
	Daniel O'Brien	)
		)
For:	Water Resistant Audible Signal	)

Honorable Commissioner
of Patents and Trademarks
Washington, D.C. 20231

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BRIEF ON APPEAL

1. INTRODUCTION

This appeal is taken from the final rejection of Claims 1-13, (attached in the Appendix as Exhibit A) -- all of the claims now pending in the above-identified application. The final rejection was made in an Office Action mailed September 5, 2002 (Exhibit C). A timely Notice of Appeal to the Board of Patent Appeals and Interferences was filed in this case on January 6, 2003. This Appeal Brief is timely filed on June 5, 2003.

2. REAL PARTY IN INTEREST

The real party in interest is Mallory Sonalert Products, Inc.

3. RELATED APPEALS AND INTERFERENCES

There are no appeals or interferences known to Appellant relevant to these proceedings.

4. STATUS OF CLAIMS

As Mallory understands, Claims 1-5 and 13 stand finally rejected under 35 U.S.C. Section 103(a) as unpatentable (1) over Siebold et al. (U.S. Patent No. 4,420,706) in view of Haertl (U.S. Patent No. 4,987,597); (2) over Hackett (U.S. Patent No. 4,042,845) in view of Marren et al. (U.S. Patent No. 5,222,050); (3) over Siebold et al. in view of Marren et al.; and (4) over Siebold et al. in view of Haertl.

Claims 6-12 stand finally rejected under 35 U.S.C. 103 as unpatentable (1) over Siebold et al. in view of Marren et al. and further in view of Press (U.S. Patent No. 6,105,214); (2) over Hackett in view of Marren et al. and further in view of Press; (3) over Siebold et al. in view of Marren et al. and further in view of press; and (4) over Siebold et al. in view of Haertl and further in view of press.

No claims have been canceled.

This appeal is taken with respect to all thirteen rejected claims, which are recited in Exhibit A in the Appendix.

5. STATUS OF AMENDMENTS

No amendment to the pending claims has been made since the date of the final rejection. In other words, the claims on appeal are the same, in all respects, as those subject to the final rejection.

6. SUMMARY OF INVENTION

The present invention is directed to a piezoelectric transducer and associated electrical circuitry for providing an improved audible alarms in a wide variety of devices and in a wide variety of conditions, including environments with water corrosion risks. Such alarms must include

a piezoelectric transducer;

a sound amplifying housing adjacent the transducer for amplifying the sound generated by the transducer; and

a water resistant, sound permeable barrier adjacent the housing for facilitating the transmission of sound generated by the transducer out of the housing, while providing a barrier for preventing liquid from entering into the housing. A further feature required in certain claims (i.e., claims 6-12) further requires that a water resistant, hydrophobic fastener for facilitating the attachment of the water resistant, sound permeable barrier to the housing. Further claims recite that the barrier should include a layer composed of PTFE (i.e., polyfluorotetraethylene). Preferred embodiments of the invention are described in the specification of the application patent at page 4, line 2, through page 6, line 17. (Exhibit B).

In summary, the present invention is directed to the problem of a signaling device that has a piezoelectric transducer for generating an audible alarm, a housing for amplifying that signal, and a water resistant sound permeable barrier that permits amplified signals to be transmitted from the housing, while preventing liquids from entering into and corroding the housing and transducer.

7. STATEMENT OF ISSUES

The issues for resolution in this appeal are:

Whether claims 1-5 and 13 are unpatentable under 35 U.S.C. § 103 over Siebold or Hackett in light of Haertl or Marren; and

Whether claims 6-12 are unpatentable under 35 U.S.C. § 103 over Siebold or Hackett in light of Haertl or Marren and further in view of Press.

8. GROUPING OF CLAIMS

Independent claim 1 is representative of all claims rejected upon the combination of Siebold or Hackett in view of Haertl or Marren (i.e., claims 1-5 and 13) and it is reproduced in its entirety immediately below:

1. A noise-making device comprising:

a piezoelectric transducer;

a sound-amplifying housing adjacent the transducer, the sound-amplifying housing enclosing a space communicating with the transducer for receiving sound waves from the transducer, the sound amplifying housing further having a front face; and

a water resistant, sound permeable barrier adjacent to said front face.

Dependant claim 7 is representative of the claims rejected upon the combination of Siebold or Hackett in view of Haertl or Marren and further in view of Press (i.e., claims 6-12). Claim 7, and claim 6 upon which it depends, is set forth in its entirety below:

6. A noise-making assembly comprising:

a piezoelectric transducer;

a sound-amplifying housing adjacent the transducer, the sound-amplifying housing enclosing a space communicating with the transducer for receiving sound waves from the transducer, the sound amplifying housing further having a front face;

a water resistant, sound permeable barrier adjacent to said front face; and

a water resistant, hydrophobic fastener, said fastener mating with said sound-amplifying housing.

7. The noise making assembly of claim 6, wherein the water resistant sound permeable barrier is integrally attached to said water resistant, hydrophobic fastener.

9. ARGUMENT

A. Introduction

The final rejection was rife with impermissible hindsight:

> The test is whether the subject matter of the claimed inventions would have been obvious to one skilled in the art at the time the inventions were made, not what would be obvious to a judge after reading the patents in suit and hearing the testimony.

Panduit Corp. v. Dennison Mfg. Co., 227 U.S.P.Q. 337, 343 (Fed. Cir. 1985).

The rejections here incorrectly used the claims as a roadmap, and then selected their elements from the prior art, exactly in the manner disapproved in Panduit. The prior art cannot be combined without a suggestion to do so, nor can it be read selectively:

> a prior patent must be considered in its entirety, i.e., as a whole, including portions that would lead away from the invention in suit; ... elements of separate prior patents cannot be combined when there is no suggestion of such combination anywhere in those patents, ... and a court should avoid hindsight....

Panduit Corp. v. Dennison Mfg. Co., 1 U.S.P.Q. 2d 1593, 1597 (Fed. Cir. 1987) (citations to other cases omitted).

Hindsight is an easy trap to fall into; it is a "tempting but forbidden zone...." Loctite Corp. v. Ultraseal Ltd., 228 U.S.P.Q. 90, 98 (Fed. Cir. 1985). Inventions must never be viewed this way:

> To imbue one of ordinary skill in the art with knowledge of the invention in suit, when no prior art reference or references of record convey or suggest that knowledge, is to fall victim to the insidious effect of a hindsight

> syndrome wherein that which only the inventor taught is used against its teacher.

W.L. Gore & Associates, Inc. v. Garlock, Inc., 220 U.S.P.Q. 303, 312-313 (Fed. Cir. 1983).

The Examiner used hindsight and selection. The Examiner took what he deemed the favorable parts of the cited references and, as discussed below, disregarded teachings which indicate that there was no suggestion to modify such references to come up with the claimed invention, such as Marren's teaching away from the use of PFTE with transducer housings (Marren, col. 1, lines 28-50), or Hackett's focus upon providing a focused beam for generating and detecting ultrasound signals (e.g., Hackett, col. 1, lines 10-17), as opposed to an audible alarm. The Examiner argues that all of the elements of the invention can be found in the references, and that anyone of skill could combine them. This kind of argument has been rejected time and again. A decision of the Federal Circuit held:

> Virtually all inventions are necessarily combinations of old elements. The notion, therefore, that combination claims can be declared invalid merely upon finding similar elements in separate prior patents would necessarily destroy virtually all patents and cannot be the law under the statute, § 103.

Panduit, 1 U.S.P.Q. 2d at 1603 (footnotes citing additional cases omitted). See also In re Wright, 6 U.S.P.Q.2d 1959, 1962 (Fed. Cir. 1988) (citing H.T. Markey, Why Not the Statute?, 65 J. Pat. Off. Soc'y 331, 333-34 (1983) ("virtually all inventions are 'combinations', and ... every invention is formed of 'old elements' .... Only God works from nothing. Man must work with old elements."). It is legally insufficient to say that all the elements of the invention can be found in the prior art.

Nor is it adequate to make an unsupported assumption that "it is extremely well known [by one of skill in the art] that a barrier formed of polytetrafluoroethylene . . . can be applied to a transducer housing" (September 5, 2002 action, page 3). The Federal Circuit has stated in no uncertain terms that there must be a suggestion or motivation to

combine the references, and that suggestion must exist in the references themselves. Interconnect Planning Corp. v. Feil, 227 U.S.P.Q. 2d 543, 551 (Fed. Cir. 1985) It is improper to use claims of the application as a frame, and use individual parts of prior art as a mosaic to recreate the claimed invention out of the prior art references. Id.

The suggestion to combine references cannot come from the applicant's invention itself. In re Oetiker, 24 U.S.P.Q. 2d 1443, 1446 (Fed. Cir. 1992); In re Geiger, 2 U.S.P.Q. 2d 1276, 1278 (Fed. Cir. 1987) ("Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching, suggestion or incentive supporting the combination."); ACS Hosp. Systems, Inc. v. Montefiore Hosp., 221 U.S.P.Q. 929, 933 (Fed. Cir. 1984) ("Under section 103, teachings of references can be combined only if there is some suggestion or incentive to do so."). And while it might be obvious to attempt to modify prior art alarm transducer housings, obvious to try is not the standard of obviousness. In re Dow Chemical Co., 5 U.S.P.Q. 2d 1529 (Fed. Cir. 1988).

In this case, no prima facie case of obviousness has been made, since the Examiner points to nothing in the cited references which suggests the claimed invention. Lindemann Maschinenfabrik GmbH v. American Hoist & Derrick Co., 221 U.S.P.Q. 481, 488 (Fed. Cir. 1984) ("Nothing in the references alone or together suggests the claimed invention as a solution to the problem"); In re Fine,5 U.S.P.Q.2d at 1599 (whether a particular combination might be "obvious to try" is not a legitimate test of patentability). See also Interconnect Planning Corp. v. Feil, 227 U.S.P.Q. 543, 547 (Fed. Cir. 1985) (When determining obviousness, "[t]he invention must be viewed not with the blueprint drawn by the inventor, but in the state of the art that existed at the time.").

B. The Examiner's Final Rejection

The Federal Circuit has repeatedly cautioned that "section 103 requires a fact-intensive comparison of the claimed process with the prior art rather than the mechanical application of one or another per se rule." In re Michihiko Ochiai, supra

(citing numerous cases). In the present case, the Examiner's final rejection ran afoul of the facts of record in the cited prior art. Namely, the examiner did not properly evaluate the prior art as a whole, including the portions teaching away from the claimed combination. The facts relied upon by the Examiner in the cited references are shown in the Office Actions attached as Exhibit C in the Appendix.

C. <u>The Evidence Of Record Shows Non-Obviousness</u>

1. Siebold Would Not Be Combined With Marren or Hackett By A Person of Ordinary Skill in the Art to Arrive at the Claimed Invention

Specifically, the Examiner states that "Claims 1-5 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Siebold et al. . . . or Hacket . . . in view of Haertl . . . or Marren et al.[.]" Further the Examiner states that "[t]he only difference between claims 1 and 13 and the device of Hackett or Siebold is that the front face of Hackett's or Siebold's unit is not provided with a water resistant or sound permeable barrier. However, as taught by either Marren . . . or Haertl . . . it is extremely well known that a barrier formed of polytetrafluoroethylene is sound permeable but water-impermeable, and can be applied to a transducer housing." Respectfully, applicant submits that it would be improper to combine the references as asserted, and that even if it were proper to combine such references, such a combination would not result in the invention as presently claimed.

The problems being addressed by Siebold on the one hand and Haertl and Marren on the other are different from each other, and thus there is no suggestion or teaching to combine such references. As the Examiner apparently admits (September 5, 2002 action at 5). Siebold does not suggest or teach the use of water barriers for sound chambers to transducer housings – rather, Siebold simply generally addresses the basic components of a transducer and the electric connection of such transducers to other circuitry. (Siebold patent, col. 1, lines 12-15).

The secondary references relied upon by the Examiner are non-analogous (at

least in the case of Haertl), and when viewed as a whole, teach away from the invention set forth in Applicant's claims. Haertl discloses an apparatus for closing openings in a hearing aid, not a transducer or transducer housing. ('597 patent, Col. 1, lines 11-12). Haertl seems particularly concerned with a removable cap and membrane combination which can be snapped on or screwed on (Col. 4, lines 1-25) to allow removal for cleaning in an ultrasound bath. (Col. 4, line 56 - col. 5, line 3). Haertl does not teach attachment to a transducer housing, nor does it teach attachment to a housing using a hot melt, sonic weld, silicone adhesive, or similar fastening means, as called for in claims 3-5.

Even to the extent that one might try to combine Haertl and a transducer housing, "obvious to try" is not the standard for establishing obviousness. And, as Marren points out, the only known attempt to combine Haertl and transducer housings failed. Past failures of others and skepticism about the claimed invention is unquestionably objective evidence of no obviousness. Marren disparages the use of a PFTE barrier in its discussion of the prior art (i.e., the Haertl patent), noting that its attempt to use polytetraflouroetyhlene as a sound permeable water barrier "introduced an unacceptable degree of sound absorption." (Col. 1, lines 28-50).

Marren does not teach or suggest the claimed water resistant, sound permeable barrier. Marren teaches a water resistant transducer housing with hydrophobic vent for ear plugs for radio equipped divers (col. 1, lines 10-15). Marren describes a housing which includes a sound chamber and a separate motor chamber which is completely sealed from the sound chamber and contains an audio frequency motor and diaphragm. (Col. 2, lines 49-68).

Marren does <u>not</u> teach the use of polytetraflouroetyhlene as a sound permeable water barrier to the sound chamber. Instead, Marren teaches the different approach of 1) using selective seal system, and 2) applying such a selective seal system for passing air freely (but not water) from the motor chamber, as opposed to the sound chamber. (Col. 3, lines 1-6). In short, the prior art as a whole (e.g., Marren) establishes that a

person of ordinary skill could not use Haertl as the basis for a workable transducer housing design.

2. Hackett Would Not Be Combined With Marren or Haertl By A Person of Ordinary Skill in the Art to Arrive at the Claimed Invention

As with Siebold, the Examiner relies upon Hackett to show that all of the elements of the claimed invention were known in a single reference except for the claimed water-resistant, sound permeable barrier. Yet, Hackett does not even provide the claimed "noise making device" called for in all the pending claims. And, like Siebold, the Examiner apparently admits that there is no suggestion or teaching to modify Hackett to add a water-resistant, sound permeable barrier. (September 5, 2002 office action at 5).

Simply put, there is no suggestion or teaching to combine Hackett with Marren or Haertl to arrive at the claimed invention. The problems being addressed by Hackett on the one hand and Haertl and Marren on the other are fundamentally different from those addressed by the claimed invention, and would tend to lead away from their combination at all, much less a combination which arrives at the claimed invention. Each of the claims in the present application call for a "noise making device," i.e., an audible alarm. Hackett is a transducer assembly which is concerned with methods for radiating and detecting energy over a controlled beam width, i.e., for ultrasound signal generation and detection. ('845 patent, col. 1, lines 7-9). Hackett is not concerned with providing an audible alarm, much less avoiding any diminishing the audibility of an alarm in order to avoid moisture damage. Hackett neither suggests a problem with nor proposes solutions to providing an audible signal transducer assembly which includes a barrier against liquids, while at the same time generating a signal that is not dampened in decibel level by the barrier. A person of ordinary skill in the art would not be led to combine a hearing aid design (Haertl) with an ultrasonic signal generator and detector (Hackett) to provide an improved alarm design which provides a water resistant front

housing face without diminishing the audible alarm signal. Nor, as Marren shows, would a designer arrive at workable transducer housing assembly simply be combining a known transducer assembly with Haertl.

D. Conclusion

The evidence of record is that Siebold or Hackett would not be combined by a person of skill in the art with Haertl or Marren. The Examiner's response is does not address the facts cited by the applicant showing how the prior art as a whole fails to arrive at the claimed invention. The evidence of record is that Siebold or Hackett in combination with Haertl or Marren would not result in the invention, but instead would (as in the case of Marren) teach away from the use of PTFE, and would not suggest using a water resistant barrier for a sound amplifying housing. The evidence of record is that no reference or combination of references fairly shows a noise making alarm including a piezoelectric transducer and a sound amplifying housing which amplifies and transmits an amplified sound while keeping out liquid from the housing chamber. Furthermore, the evidence of record fails to show or suggest the invention as claimed in claim 6-12, that is, a noise making alarm including a piezoelectric transducer and a sound amplifying housing with a water resistant hyrdrophobic fastener for securing the water resistant, sound permeable barrier to the housing.

Claims 1 to 13 should be allowed.

Respectfully submitted,

Dated: June 5, 2003

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INDEX FOR APPENDIX

A. **Pending Claims On Appeal (1-13)**
(Attached as Exhibit A)

B **The '981 Application**
(Attached as Exhibit B)

C. **Examiner's Office Actions**
(Attached as Exhibit C, in chronological order)

D. **References**
(Attached as Exhibit D, in alphabetical order)

EXHIBIT A

EXHIBIT A

PENDING CLAIMS ON APPEAL

1. A noise-making device comprising:

a piezoelectric transducer;

a sound-amplifying housing adjacent the transducer, the sound-amplifying housing enclosing a space communicating with the transducer for receiving sound waves from the transducer, the sound amplifying housing further having a front face; and

a water resistant, sound permeable barrier adjacent to said front face.

2. The noise-making device of claim 1, wherein the water resistant, sound permeable barrier is constructed of polytetrafluoroethylene.

3. The noise making device of claim 1, wherein the water resistant, sound permeable barrier is constructed of polytetrafluoroethylene and is attached to the front face by a sonic weld.

4. The noise making device of claim 1, wherein the water resistant, sound permeable barrier is constructed of polytetrafluoroethylene and is attached to the front face by a hot melt.

5. The noise making device of claim 1, wherein the water resistant, sound permeable barrier is constructed of polytetrafluoroethylene and is attached to the front face by a silicone adhesive.

6. A noise-making assembly comprising:

a piezoelectric transducer;

a sound-amplifying housing adjacent the transducer, the sound-amplifying housing enclosing a space communicating with the transducer for receiving sound waves from the transducer, the sound amplifying housing further having a front face;

a water resistant, sound permeable barrier adjacent to said front face; and

a water resistant, hydrophobic fastener, said fastener mating with said sound-amplifying housing.

7. The noise making assembly of claim 6, wherein the water resistant sound permeable barrier is integrally attached to said water resistant, hydrophobic fastener.

8. The noise making assembly of claim 6, wherein the water resistant, sound permeable barrier is constructed of polytetrafluoroethylene.

9. The noise making assembly of claim 6, wherein the water resistant, hydrophobic fastener threadingly engages said sound amplifying housing.

10. The noise making assembly of claim 6, wherein the front face of said sound amplifying housing includes at least one aperture.

11. The noise making assembly of claim 6, wherein the front face of said sound amplifying housing comprises a grill.

12. The noise making assembly of claim 6, wherein the front face of said sound amplifying housing is constructed of polytetrafluoroethylene.

13. A noise-making device comprising:

a piezoelectric transducer;

a housing adjacent the transducer, the sound-amplifying housing enclosing a space communicating with the transducer for receiving sound waves from the transducer, the housing further having a front face; and

a polytetrafluoroethylene barrier adjacent to said front face.

EXHIBIT B

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

TITLE:	WATER RESISTANT AUDIBLE SIGNAL
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ATTORNEY DOCKET NO.:	2909

Background of the Invention

The present invention relates to an improved audible signal to provide audible alarms in a wide variety of devices including, for example, automobiles and trucks, industrial equipment, medical devices, traffic signals, appliances and the like. Such devices can use a piezoelectric transducer and associated circuitry to produce sound at a given frequency. The transducer flexes in response to an applied voltage. If an oscillating voltage is applied to the transducer at an appropriate rate, the flexing of the transducer produces an audible sound of substantial volume. As the wide variety of potential uses shown above suggests, these audible signals need to be able to operate in a wide variety of conditions and environments. One problem facing such audible signals is water corrosion. Audible signals have always had a problem with liquids being able to gather in the front of the housing. Once the front of the audible signal housing fills with liquid, it is only a matter of time before the transducer corrodes and failures occur. In addition, the audible signal cannot emit a sound if there is an accumulation of liquid sitting on the transducer. Currently, audible alarms containing a piezoelectric transducers must be turned upside down to protect them from buildups of liquid in the front of the housing.

What is needed is an audible signal which includes a barrier against liquids, while at the same time generating a signal that is not dampened in decibel level by the barrier.

In the invention, the audible signal is sealed by a hydrophobic material, such as polytetrafluoroethylene (PTFE). Typically, a disc of such material can be suitably attached to the audible signal by means of a hot melt, sonic weld, silicone adhesive, or similar fastening means.

Such a hydrophobic material will result in an audible signal which is at least water resistant, while not materially affecting the decibel level or tone of the audible signal.

Summary of the Invention

According to the invention, there is provided a piezoelectric transducer and associated electrical circuitry to cause the transducer to oscillate at a resonant audible frequency. United States Patent No. 5,990,784 "Schmitt Trigger Loud Alarm With Feedback," is incorporated by reference herein and describes an alarm device using a piezoelectric transducer, and the circuitry used to perform such function. This patent is owned by the assignee of the present invention. Typically, the housing of the transducer is hollow, and can include multiple sections with different diameters. The sound generated by the piezoelectric element and amplified within the chambers or cavities of the housing preferably are emitted through a grill or spaces within the last cavity. One example of such a configuration, which is incorporated by reference, is shown in United States Patent Application 09/488,693, entitled "Extra Loud Low Frequency Acoustical Alarm Assembly," which was filed January 20, 2000 and is assigned to the assignee of the present invention.

In this housing configuration, the transducer is mounted to a proximal tubular housing which is hollow, thus providing a first cavity. A second or distal tubular housing forms a second cavity adjoining the first cavity, and is of larger diameter than the first cavity. A third cavity adjoining the second cavity may optionally be employed. Sound is produced by the transducer and passes through the first cavity, second cavity and, if used, the third cavity. The sound is emitted through a grill on the last cavity. The present invention adds to this housing configuration by

adding a hydrophobic material (such as PTFE) which is attached to the front of the audible signal housing in order to block out, or at least resist any liquids from accumulating, while avoiding any significant dampening of the decibel level of the alarm signal.

The following terms are used in the claims of the patent as filed and are intended to have their broadest meaning consistent with the requirements of law.

A "front face" can include a front surface, grill or aperture through which sound generated by a piezoelectric transducer is designed to pass.

A "water resistant, sound permeable barrier adjacent the front face" can include a covering which is affixed to a front face surface or grill of a sound amplifying housing, and it can also include a hydrophobic, sound permeable surface affixed to the aperture defining the front face.

Where alternative meanings are possible, the broadest meaning is intended. All words used in the claims set forth below are intended to be used in the normal, customary usage of grammar and the English language.

Description of the Drawings

Figure 1 is an exploded perspective schematic of the improved audible signal in conjunction with a mating knurled nut.

Figure 2 is a cross-section of the noise-making device including the water resistant barrier of the present invention.

Figure 3 is another cross-section of the improved noise-making device including the water resistant barrier and dimensions which have been determined to optimize the amplification.

Detailed Description of the Invention

Set forth below is a description of what is currently believed to be the preferred embodiment or best example of the invention claimed. Future and present alternative and modifications to this preferred embodiment are contemplated. Any alternatives or modifications which make insubstantial changes in function, in purpose, in structure or in result are intended to be covered by the claims of this patent.

Referring to Figures 1 and 2, the present invention is directed to an improved housing and assembly for a piezoelectric transducer. The assembly includes piezoelectric transducer housing 11, having a front grill 10 covered by a hydrophobic barrier 23. The barrier 23, is most preferable made from PTFE, since this material is known to be water resistant, but is not known to affect the sound of the piezoelectric transducer. However, those of ordinary skill in the art having the present teaching in hand will be able to substitute alternative appropriate barriers which have similar sound permeating features. The housing preferably is mated with a knurled nut, 31, for mounting or fastening. The knurled nut 31 is likewise constructed from a similar hydrophobic material, or it can have a hydrophobic barrier 23 which can also act to block liquids from the piezoelectric housing 11. Alternatively, the knurled nut may not cover the front grill when attached to the housing, but might nonetheless be preferably constructed of a hydrophobic material in order to avoid mechanical degradation. The knurled nut preferably mates with the housing 11 by means of a threaded fit, such as the thread 24 shown in Figure 2.

The hydrophobic barrier 23 is most preferably formed from PTFE which is cut into discs. These discs are attached to the housing by means of a hot melt, sonic weld, silicon adhesive, or

other permanent attachment. In an alternative embodiment, the front face or grill 10 of housing 11 might itself be made of PTFE in order to provide water resistant features.

Referring now to Figures 2 and 3, the housing is shown to contain a piezoelectric transducer 18. Transducer 18 is mounted at its nodal diameter to a knife-edge 17 at an end of a housing insert 16. Adhesive 19 binds the transducer 18 to the knife-edge 17. Knife-edge 17 supports the transducer 18 while at the same time allowing the transducer to flex when a voltage is applied to it. Mounting the transducer at its nodal diameter minimizes interference with flexing of transducer 18.

Housing insert 16 is cylindrical in cross-section and hollow, forming a sound-amplifying cavity 15 next to the transducer 18. One suitable material for housing insert 16 is 6/6 nylon or "ABS." A source for 6/6 nylon is Zytel 101 available from Pro Tech Plastic Inc., 1295 West Helena Drive, West Chicago, Illinois, 60185. The length "A" of housing 16 is adjusted to maximize the amplification.

A main housing 11 is cylindrical in cross-section and hollow. Main housing 11 is attached to an end of housing insert 16. A flange 21 on main housing 11 engages and is secured by any convenient means to a flange 22 on insert 16. Main housing 11 is hollow, and has two cylindrical sections with different diameters. One cylindrical section forms a sound-amplifying cavity 13, and a second larger cylindrical section forms another sound-amplifying cavity 14. The diameters of cavities 13 and 15 are typically about the same, whereas the diameter "B" of cavity 14 is larger. A grill 10 may be attached to the end of housing 11 away from the transducer 18, and allows sound produced by the transducer, and amplified in the cavities, to be emitted and heard.

Figure 3 shows the invention with dimensions that have been found to produce a sound increase of about 10 to 15 dbA compared to devices using the same transducer and circuitry, but lacking the housing insert 16 and therefore having only one cavity. Dimension "A" is 0.438 inches. Dimension "B" is 1.460 inches. Dimension "C" is 0.088 inches. Dimension "D" is 0.492 inches. The diameters of housing 11 and housing insert 16 are 0.875 inches, approximately the same as the nodal diameter of transducer 18.

The above description is not intended to limit the meaning of the words used in the following claims that define the invention. Rather, it is contemplated that future modifications in structure, function or result will exist that are not substantial changes and that all such insubstantial changes in what is claimed are intended to be covered by the claims. For instance, the preferred embodiment of the present invention focuses upon a hydrophobic PTFE cover attached to the housing -- however, the advantages of the present invention could be equally applicable to a wide array of hydrophobic materials, and the invention is likewise intended to cover a housing front face constructed out of such hydrophobic materials. Likewise, it will be appreciated by those skilled in the art that various changes, additions, omissions, and modifications can be made to the illustrated embodiments without departing from the spirit of the present invention. All such modifications and changes are intended to be covered by the following claims.

We claim:

1. A noise-making device comprising:

a piezoelectric transducer;

a sound-amplifying housing adjacent the transducer, the sound-amplifying housing enclosing a space communicating with the transducer for receiving sound waves from the transducer, the sound amplifying housing further having a front face; and

a water resistant, sound permeable barrier adjacent to said front face.

2. The noise-making device of claim 1, wherein the water resistant, sound permeable barrier is constructed of polytetrafluoroethylene.

3. The noise making device of claim 1, wherein the water resistant, sound permeable barrier is attached to the front face by a sonic weld.

4. The noise making device of claim 1, wherein the water resistant, sound permeable barrier is attached to the front face by a hot melt.

5. The noise making device of claim 1, wherein the water resistant, sound permeable barrier is attached to the front face by a silicone adhesive.

6. A noise-making assembly comprising:

a piezoelectric transducer;

a sound-amplifying housing adjacent the transducer, the sound-amplifying housing enclosing a space communicating with the transducer for receiving sound waves from the transducer, the sound amplifying housing further having a front face;

a water resistant, sound permeable barrier adjacent to said front face; and

a water resistant, hydrophobic fastener, said fastener mating with said sound-amplifying housing.

7. The noise making assembly of claim 6, wherein the water resistant sound permeable barrier is integrally attached to said water resistant, hydrophobic fastener.

8. The noise making assembly of claim 6, wherein the water resistant, sound permeable barrier is constructed of polytetrafluoroethylene

9. The noise making assembly of claim 6, wherein the water resistant, hydrophobic fastener threadingly engages said sound amplifying housing.

10. The noise making assembly of claim 6, wherein the front face of said sound amplifying housing includes at least one aperture.

11. The noise making assembly of claim 6, wherein the front face of said sound amplifying housing comprises a grill.

12. The noise making assembly of claim 6, wherein the front face of said sound amplifying housing is constructed of polytetrafluoroethylene.

13. A noise-making device comprising:

a piezoelectric transducer;

a housing adjacent the transducer, the sound-amplifying housing enclosing a space communicating with the transducer for receiving sound waves from the transducer, the housing further having a front face; and

a polytetrafluoroethylene barrier adjacent to said front face.

Abstract

The invention is an modified audible signal, such as a piezoelectric noise-making and audible signaling device, which further includes a hydrophobic covering material, such as polytetrafluoroethylene (PTFE). The hydrophobic covering material is known to be water resistant, but does not effect the sound of the audible signaling device, thereby delaying or preventing the failure of the audible signaling device from water corrosion.

NORTH AMERICAN CAPACITOR COMPANY MALLORY
INDIANAPOLIS, INDIANA U.S.A.

REVISION	SHEET OF	PART NO.

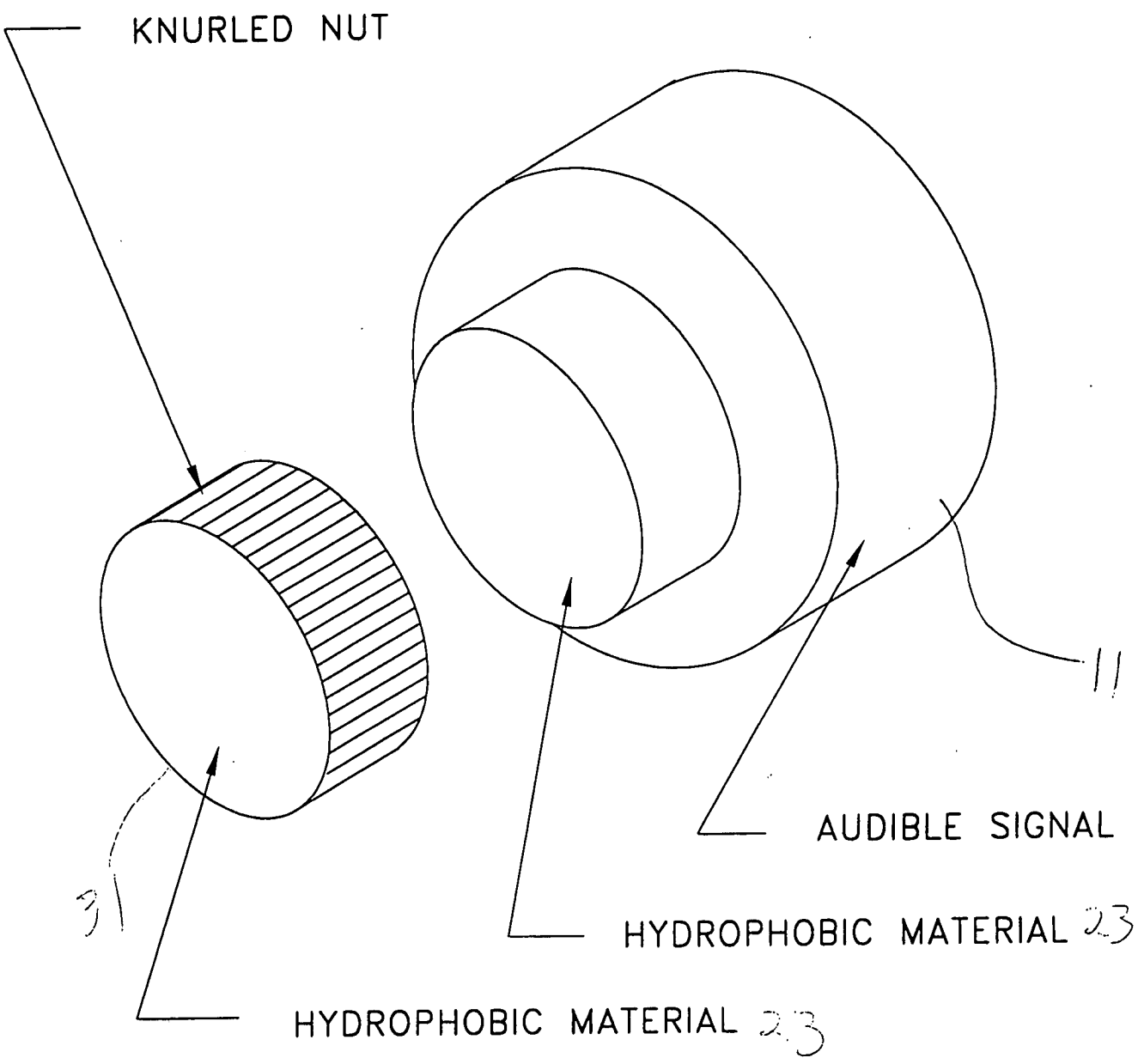


Figure #1

TITLE

Extra Loud Audible Signal Sound Cavity

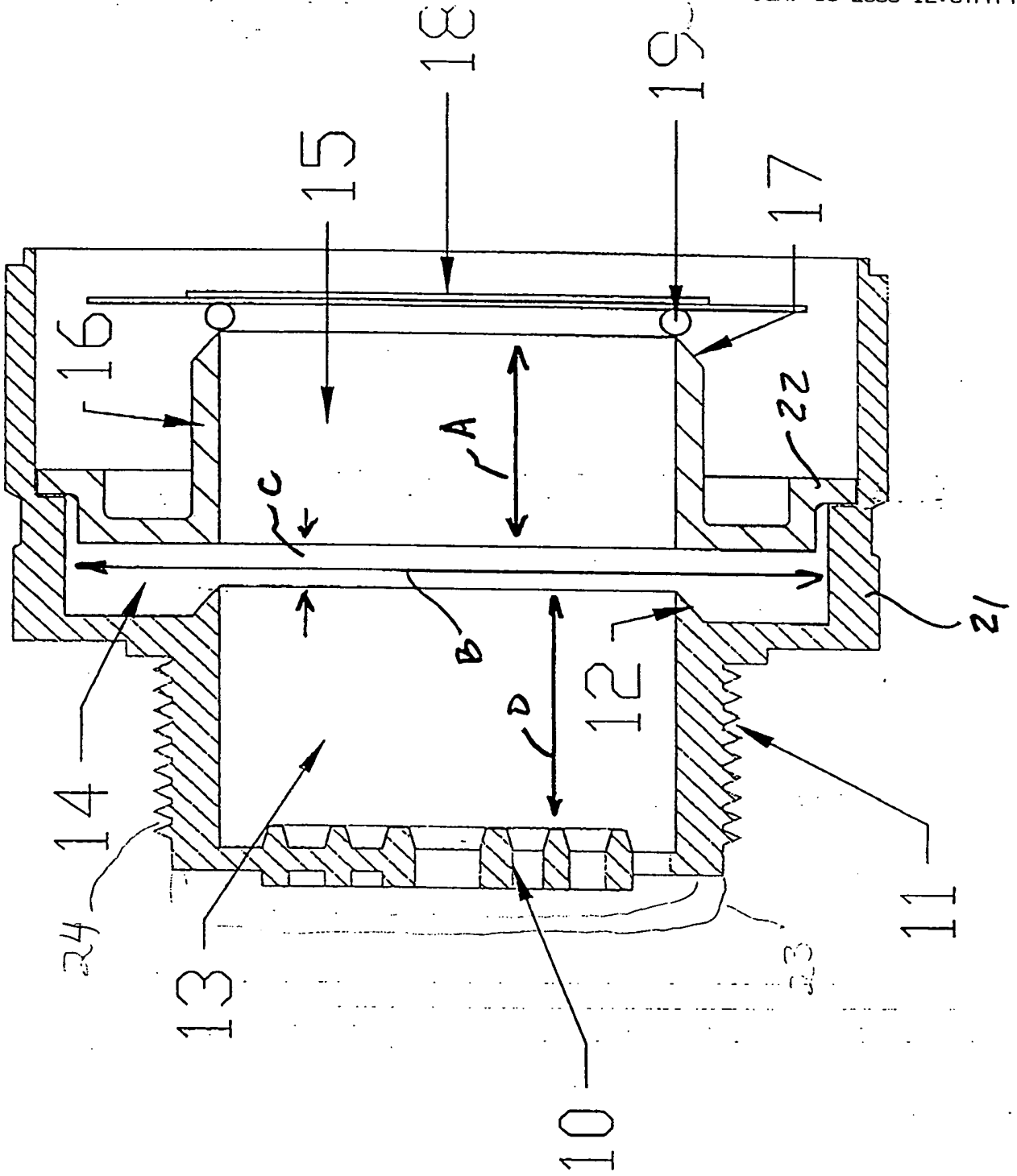
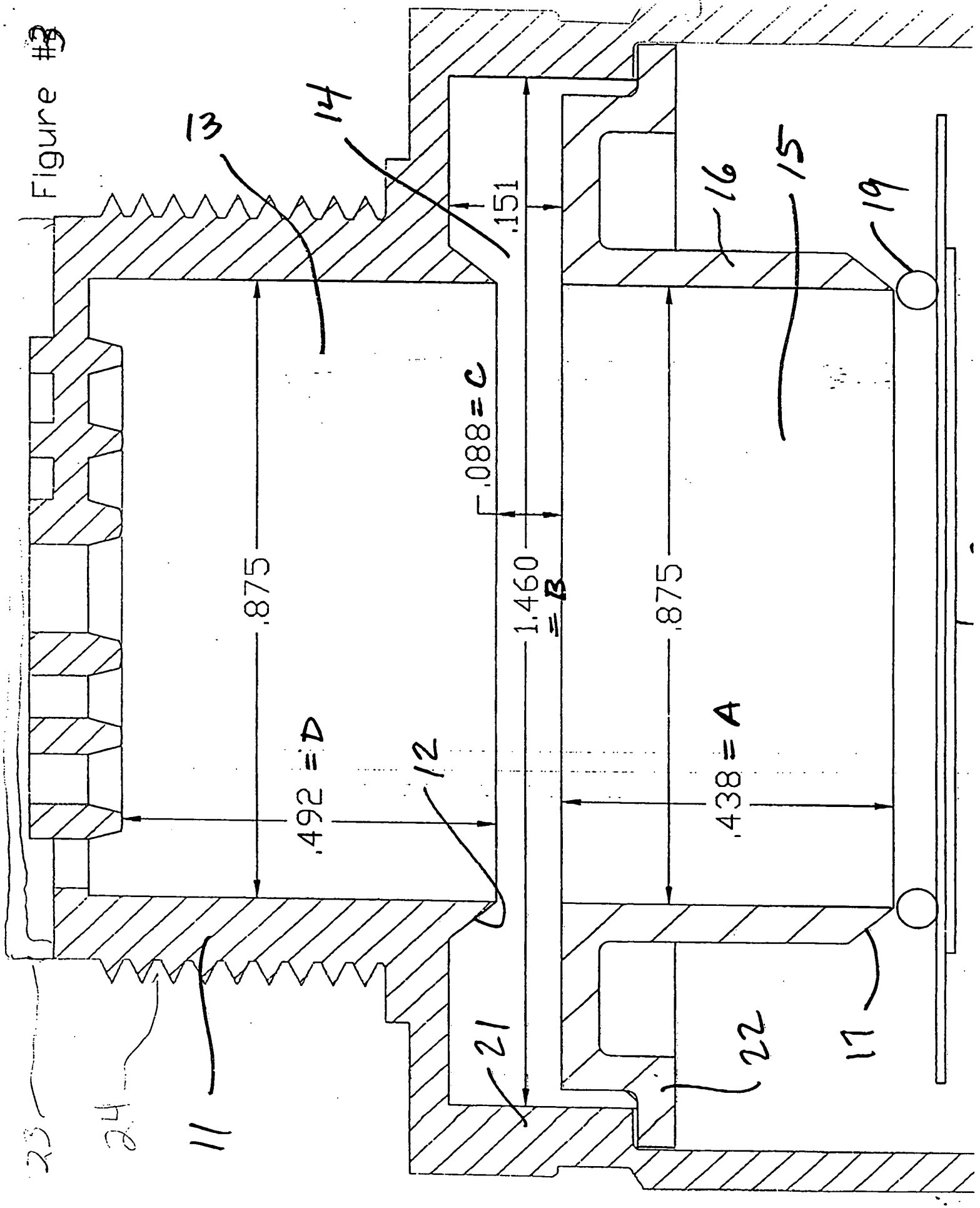


Figure #3


13
14
.151
16
15
19
.088 = C
.875
1.460 = B
.875
.492 = D
12
.438 = A
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22
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24

Practitioner's Docket No. 2909

PATENT

COMBINED DECLARATION AND POWER OF ATTORNEY

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION, OR C-I-P)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is for an original application.

INVENTORSHIP IDENTIFICATION

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am an original, first and joint inventor of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

WATER RESISTANT AUDIBLE SIGNAL

SPECIFICATION IDENTIFICATION

The specification is attached herewith.

ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, § 1.56.

POWER OF ATTORNEY

I hereby appoint the following practitioner(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Raymond P. Niro	Registration No. 24,131
Thomas G. Scavone	Registration No. 26,801
Timothy J. Haller	Registration No. 26,692
Joseph N. Hosteny	Registration No. 28,020
Robert A. Vitale, Jr.	Registration No. 32,319
John C. Janka	Registration No. 32,996
Michael P. Mazza	Registration No. 34,092
Dean D. Niro	Registration No. 36,881
Keith A. Vogt	Registration No. 37,252
Arthur A. Gasey	Registration No. 35,150
Robert P. Greenspoon	Registration No. 40,004
Christopher J. Lee	Registration No. 41,934
Richard B. Megley, Jr.	Registration No. 41,992
Vasilios D. Dossas	Registration No. 30,745
Robert F. Meyer	Registration No. 22,048

SEND CORRESPONDENCE TO

Joseph N. Hosteny
Niro, Scavone, Haller & Niro
181 West Madison Street Suite 4600
Chicago, IL 60602

DIRECT TELEPHONE CALLS TO:

Joseph N. Hosteny
(312) 236-0733

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE(S)

George A. Burnett
Inventor's signature George A. Burnett
Date 9/15/00 **Country of Citizenship** United States
Residence Clayton, Indiana
Post Office Address P.O. Box 21
Clayton, Indiana 46118
United States

Joshua K. Brown
Inventor's signature Joshua Brown
Date 9/15/00 **Country of Citizenship** United States
Residence Indianapolis, Indiana
Post Office Address 93 Beachway Drive
Indianapolis, Indiana 46224
United States

Daniel W. O'Brien
Inventor's signature Daniel W. O'Brien
Date 9/15/00 **Country of Citizenship** United States
Residence Mooresville, Indiana
Post Office Address 1711 Hill Road
Mooresville, Indiana 46158
United States

Practitioner's Docket No. 2909 *PATENT*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: George A. Burnett et al.
Application No.: New Application
Filed: Herewith
Title: WATER RESISTANT AUDIBLE SIGNAL

STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27(b) - SMALL BUSINESS CONCERN

I hereby state that the above identified small business concern qualifies as a small business concern, as defined in 13 CFR 121.12, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office under Sections 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third-party or parties controls or has the power to control both.

I hereby state that rights under contract or law have been conveyed to, and remain with, the small business concern identified above, with regard to the invention described in the application identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights in the invention is listed below and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c), if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each such person, concern or organization having any rights in the invention is listed below:

No such person, concern, or organization exists.

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small business entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed..

Date: 9/15/00

Signature of Thomas L. Arnold
President, Yosemite Investments, Inc.
7545 Rockville Road
P.O. Box 1284
Indianapolis, IN 46206-1284
United States

Docket No.: 2909

FORM PTO-1595 (Modified)
(Rev. 6-93)
OMB No. 0651-0011 (exp.4/94)
Copyright 1994-97 LegalStar
P08/REV02

RECORDATION FORM COVER SHEET

PATENTS ONLY

U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Offic

Tab settings ▼ ▼ ▼ ▼ ▼ ▼ ▼

To the Honorable Commissioner of Patents and Trademarks: Please record the attached original documents or copy thereof.

1. Name of conveying party(ies):
George A. Burnett
Joshua K. Brown
Daniel W. O'Brien

Additional names(s) of conveying party(ies) ☐ Yes ☒ No

2. Name and address of receiving party(ies):

Name: **Yosemite Investments, Inc.**

Internal Address:

Street Address: **7545 Rockville Road**

City: **Indianapolis** State: **IN** ZIP: **46206-**

Additional name(s) & address(es) attached? ☐ Yes ☒ No

3. Nature of conveyance:

☒ Assignment ☐ Merger

☐ Security Agreement ☐ Change of Name

☐ Other

Execution Date: **September 15, 2000**

4. Application number(s) or registration numbers(s):

If this document is being filed together with a new application, the execution date of the application is: **September 15, 2000**

A. Patent Application No.(s)

B. Patent No.(s)

Additional numbers attached? ☐ Yes ☒ No

5. Name and address of party to whom correspondence concerning document should be mailed:

Name: **Arthur A. Gasey**

Internal Address: **Suite 4600**

Street Address: **181 W. Madison**

City: **Chicago** State: **IL** ZIP: **60602**

6. Total number of applications and patents involved: **1**

7. Total fee (37 CFR 3.41):.....$ **40.00**

☒ Enclosed - Any excess or insufficiency should be credited or debited to deposit account

☐ Authorized to be charged to deposit account

8. Deposit account number:

14-1131

DO NOT USE THIS SPACE

9. Statement and signature.

To the best of my knowledge and belief, the foregoing information is true and correct and any attached copy is a true copy of the original document.

Hannah Martin — Name of Person Signing

Signature

September 22, 2000 — Date

Total number of pages including cover sheet, attachments, and document: **3**

Practitioner's Docket No. 2909

PATENT

For: U.S. Rights and Foreign Rights
For: U.S. Application
By: Inventor

ASSIGNMENT OF INVENTION

In consideration of the payment by ASSIGNEE to ASSIGNOR of the sum of One Dollar ($1.00), the receipt of which is hereby acknowledged, and for other good and valuable consideration,

ASSIGNOR(S):

George A. Burnett
P.O. Box 21
Clayton, Indiana 46118
United States Citizen

Joshua K. Brown
93 Beachway Drive
Indianapolis, Indiana 46224
United States Citizen

Daniel W. O'Brien
1711 Hill Road
Mooresville, Indiana 46158
United States Citizen

hereby sell, assign and transfer to

ASSIGNEE:

Yosemite Investments, Inc.
7545 Rockville Road
P.O. Box 1284
Indianapolis, Indiana 46206-1284
United States

and the successors, assigns and legal representatives of the ASSIGNEE the entire right, title and interest for the United States and its territorial possessions and in all foreign countries, including all rights to claim priority, in and to any and all improvements which are disclosed in the invention entitled:

WATER RESISTANT AUDIBLE SIGNAL

and which is found in (37 C.F.R. § 3.21) U.S. patent application executed on even date herewith and any legal equivalent thereof in a foreign country, including the right to claim priority and, in and to, all Letters

Patent to be obtained for said invention by the above application or any continuation, division, renewal, or substitute thereof, and as to letters patent any reissue or re-examination thereof.

ASSIGNOR hereby covenants that no assignment, sale, agreement or encumbrance has been or will be made or entered into which would conflict with this assignment.

ASSIGNOR further covenants that ASSIGNEE will, upon its request, be provided promptly with all pertinent facts and documents relating to said invention and said Letters Patent and legal equivalents as may be known and accessible to ASSIGNOR and will testify as to the same in any interference, litigation or proceeding related thereto and will promptly execute and deliver to ASSIGNEE or its legal representatives any and all papers, instruments or affidavits required to apply for, obtain, maintain, issue and enforce said application, said invention and said Letters Patent and said equivalents thereof which may be necessary or desirable to carry out the purposes thereof.

Date: 9/15/00

George A. Burnett

Signature of George A. Burnett

Date: 9/15/00

Joshua Brown

Signature of Joshua K. Brown

Date: 9/15/00

Daniel W. O'Brien

Signature of Daniel W. O'Brien

EXHIBIT C

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/667,981	09/22/2000	George A. Burnett	2909	1090

7590 09/05/2002

Joseph N Hosteny
Niro Scavone Haller & Niro
Suite 4600
181 West Madison Street
Chicago, IL 60602

EXAMINER
HUANG, SIHONG

ART UNIT	PAPER NUMBER
2632	6

DATE MAILED: 09/05/2002

Final Amendment / Res NO Appeal
Response due 12/5/02 LTB

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/667,981	BURNETT ET AL.	
	Examiner	Art Unit	
	Sihong Huang	2632	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *11 June 2002* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-13* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-13* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Response to Amendment

This Office Action is responsive to the amendment filed on June 11, 2002. As directed by the amendment, no claim is canceled, claims 3-5 and 8 are amended, and no new claim is added. Thus, claims 1-13 are presently pending in this patent application with claims 1, 6 and 13 being the independent claims.

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 1-5 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Siebold et al. (U.S. Pat. No. 4,420,706) or Hackett (U.S. Pat. No. 4,042,845) in view of Haertl (U.S. Pat. No. 4,987,597) or Marren et al. (U.S. Pat. No. 5,222,050).

Regarding claims 1 and 13, Siebold et al or Hackett disclosed an noise or sound device comprising: a piezoelectric transducer (col. 3, lines 20-24 of Siebold or 12 of Hackett) and a sound-amplifying housing (sound chamber 66 and 68 and col. 4, lines 17-20 of Siebold or the Helmholtz chamber 11 and col. 3, lines 40-55 of Hackett), said housing includes a front face (14 of Hackett or the surface where the hole is formed). The only difference between claims 1 and 13 and the device of Hackett or Siebold is that the front face of Hackett's or Siebold's unit is not provided with a water resistant, sound permeable barrier. However, as taught by either Marren

(col. 1, lines 28-39) or Haertl (col. 3, lines 11-32), it is extremely well known that a barrier formed of polytetrafluoroethylene is sound permeable but water-impermeable, and can be applied to a transducer housing. In fact, such water resistant and sound permeable barriers are so well known, a person with ordinary skill can buy them under the Trademark name GORE-TEX. They are also sold by W.L. Gore & Associates, Inc. Therefore, they are also commercially available. The advantage of providing such barriers is water resistant or waterproof, and generally able to protect the driver elements or transducer element from moisture and other contaminants. Since a person with ordinary skill would have recognized that adding such barriers will allow the device of either Siebold or Hackett to resist water for damaging the transducer element or other elements inside the housing, and to protect those elements from moisture and other contaminants, it would have been extremely obvious to an artisan at the time of the invention to apply the barrier as taught by either Marren or Haertl to the device of Hackett or Siebold in order to add the advantage as described above.

Regarding claim 2, the barrier of Marren or Haertl is formed of polytetrafluoroethylene.

Regarding claims 3-5, the barrier of Marren or Haertl is formed of polytetrafluoroethylene. Although Haertl does not specifically disclose the claimed methods to attach the barrier to the front face (e.g., by a sonic weld, a hot melt or silicone adhesive), Haertl in col. 3, lines 27-33 clearly discloses that PTFE is chemically insert and not affected by any common chemical, it has a low friction coefficient, functions within a wide temperature range, does not age, and is weather durable, it is also porous, air permeable, extremely strong, hydrophobic, and biocompatible. Thus, attaching such barrier to the front face by a sonic weld, a hot melt or silicone adhesive is merely a matter of engineering design, and all these mounting

methods are extremely well known and would have been an obvious modification to the modified device mentioned above.

3. Claims 6-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Siebold et al. (U.S. Pat. No. 4,420,706) or Hackett (U.S. Pat. No. 4,042,845) in view of Haertl (U.S. Pat. No. 4,987,597) or Marren et al. (U.S. Pat. No. 5,222,050) as applied to claims 1-5 and 13 above, and further in view of Press (U.S. Pat. No. 6,105,214).

Regarding claim 6, the modified device of Siebold or Hackett and Marren or Haertl differs from claim 6 in that it does not show a water resistant, hydrophobic fastener for mating the housing. However, as evidenced by Press, providing a hydrophobic fastener for water resistant is extremely well known (col. 1, lines 5-25). A person with ordinary skill would have easily recognized that if one wants to protect his/her sound device from water or moisture and other contaminants, one can easily apply any well known type of water resistant material (such as the one taught by Press) to cover the sound device (such as the one shown by Siebold or Hackett) in order to take the advantage as described above. Therefore, it would have been extremely obvious to coat the housing of either Siebold or Hackett with any type of well known water resistant material including those shown by Press for the purpose of protect the device from water or moisture and other contaminants.

Regarding claims 7-9 and 12, the modified device as described above will have both the sound permeable barrier and fastener. As disclosed in claims 1, 2 and 13 above, using polytetrafluoroethylene as housing component is extremely well known in the art and would have been an obvious modification to the above modified device.

Regarding claims 10 and 11, both Hackett and Siebold clearly illustrated that the housing has at least one aperture. Also, whether to form an aperture or a grill would have been an obvious design choice. Furthermore, a housing has a hole or grill is extremely well known in the art and would have been an obvious modification to the modified device mentioned above.

Response to Arguments

4. Applicant's arguments filed June 11, 2002 have been fully considered but they are not persuasive.

5. Applicant in the remarks argues that the problems being addressed by Siebold and Hackett on one hand and Haertle and Marren on the other are different from each other, and thus there is no suggestion or teaching to combine such references. In response to applicant's argument that there is no suggestion to combine the references, the examiner recognizes that obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988) and *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). In this case, the reasons for combining the references are clearly stated in the rejections. In addition, Siebold and Hackett are applied to show a known noise-making device/assembly in the art, not the problems they try to solve, and the secondary references Marren and Haertl are applied to teach the use of water resistant and sound permeable barriers which are formed of polytetrafluoroethylene in electronic device. Furthermore, the Marren reference is cited to further define the use of polytetrafluorethylene in electronic device as disclosed in the Haertl (Pat. No. 4,987,597)

reference (see rejection above for pointing to col. 1, lines 28-39 of Marren concerning the Haertl reference).

6. In response to applicant's argument that Haertl does not teach attachment to a transducer housing, nor does it teach attachment to a housing using a hot melt, sonic weld, silicone adhesive, or similar fastening means, as called for in claims 3-5, applicant is advised to see the rejection above to claims 3-5 for details.

7. In response to applicant's argument that Press reference is nonanalogous art, it has been held that a prior art reference must either be in the field of applicant's endeavor or, if not, then be reasonably pertinent to the particular problem with which the applicant was concerned, in order to be relied upon as a basis for rejection of the claimed invention. See *In re Oetiker*, 977 F.2d 1443, 24 USPQ2d 1443 (Fed. Cir. 1992). In this case, the Press reference is applied to show that providing a hydrophobic fastener for water resistant is extremely well known and therefore an obvious modification to the combination of Siebold, Hackett, Marren and Haertl.

Conclusion

8. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event,

however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

9. Any response to this final action should be mailed to:

Box AF

Commissioner of Patents and Trademarks

Washington, D.C. 20231

or faxed to:

(703) 872-9314, (for formal communications; please mark "EXPEDITED PROCEDURE")

Or:

(703) 872-9314, (for informal or draft communications, please label "PROPOSED" or "DRAFT")

Hand-delivered responses should be brought to Crystal Park II, 2121 Crystal Drive, Arlington. VA., Sixth Floor (Receptionist).

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Sihong Huang whose telephone number is (703) 305-3966.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jeffery Hofsass, can be reached on (703) 305-4717.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Customer Service Office whose telephone number is (703) 306-0377.

S. Huang

August 28, 2002

DANIEL J WU
Primary Examiner
9/04/02

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/667,981	09/22/2000	George A. Burnett	2909	1090

7590 12/20/2001

Joseph N Hosteny
Niro Scavone Haller & Niro
Suite 4600
181 West Madison Street
Chicago, IL 60602

EXAMINER
HUANG, SIHONG

ART UNIT	PAPER NUMBER
2632	

DATE MAILED: 12/20/2001

Please find below and/or attached an Office communication concerning this application or proceeding.

Response Due March 20, 2002
c/o Feb 20, 2002

Office Action Summary	Application No.	Applicant(s)	
	09/667,981	BURNETT ET AL.	
	Examiner	Art Unit	
	Sihong Huang	2632	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *22 September 2000* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-13* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-13* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 2 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Specification

1. The disclosure is objected to because of the following informalities:

In line 1 of the abstract, "an modified" should read –a modified--.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

2. Claim 8 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 8 is vague and indefinite because an end period is missing.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-5 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Siebold et al. (U.S. Pat. No. 4,420,706) or Hackett (U.S. Pat. No. 4,042,845) in view of Haertl (U.S. Pat. No. 4,987,597) or Marren et al. (U.S. Pat. No. 5,222,050).

Regarding claims 1 and 13, Siebold et al or Hackett disclosed an noise or sound device comprising: a piezoelectric transducer (col. 3, lines 20-24 of Siebold or 12 of Hackett) and a sound-amplifying housing (sound chamber 66 and 68 and col. 4, lines 17-20 of Siebold or the Helmholtz chamber 11 and col. 3, lines 40-55 of Hackett), said housing includes a front face (14

of Hackett or the surface where the hole is formed). The only difference between claims 1 and 13 and the device of Hackett or Siebold is that the front face of Hackett's or Siebold's unit is not provided with a water resistant, sound permeable barrier. However, as taught by either Marren (col. 1, lines 28-39) or Haertl (col. 3, lines 11-32), it is extremely well known that a barrier formed of polytetrafluoroethylene is sound permeable but water-impermeable, and can be applied to a transducer housing. In fact, such water resistant and sound permeable barriers are so well known, a person with ordinary skill can buy them under the Trademark name GORE-TEX. They are also sold by W.L. Gore & Associates, Inc. Therefore, they are also commercially available. The advantage of providing such barriers is water resistant or waterproof, and generally able to protect the driver elements or transducer element from moisture and other contaminants. Since a person with ordinary skill would have recognized that adding such barriers will allow the device of either Siebold or Hackett to resist water for damaging the transducer element or other elements inside the housing, and to protect those elements from moisture and other contaminants, it would have been extremely obvious to an artisan at the time of the invention to apply the barrier as taught by either Marren or Haertl to the device of Hackett or Siebold in order to add the advantage as described above.

Regarding claim 2, the barrier of Marren or Haertl is formed of polytetrafluoroethylene.

Regarding claims 3-5, whether attaching the barrier to the front face by a sonic weld, a hot melt or silicone adhesive is merely a matter of engineering design. Furthermore, all these mounting methods are extremely well known and would have been an obvious modification to the modified device mentioned above.

5. Claims 6-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Siebold et al. (U.S. Pat. No. 4,420,706) or Hackett (U.S. Pat. No. 4,042,845) in view of Haertl (U.S. Pat. No. 4,987,597) or Marren et al. (U.S. Pat. No. 5,222,050) as applied to claims 1-5 and 13 above, and further in view of Press (U.S. Pat. No. 6,105,214).

Regarding claim 6, the modified device of Siebold or Hackett and Marren or Haertl differs from claim 6 in that it does not show a water resistant, hydrophobic fastener for mating the housing. However, as evidenced by Press, providing a hydrophobic fastener for water resistant is extremely well known (col. 1, lines 5-25). A person with ordinary skill would have easily recognized that if one wants to protect his/her sound device from water or moisture and other contaminants, one can easily apply any well known type of water resistant material (such as the one taught by Press) to cover the sound device (such as the one shown by Siebold or Hackett) in order to take the advantage as described above. Therefore, it would have been extremely obvious to coat the housing of either Siebold or Hackett with any type of well known water resistant material including those shown by Press for the purpose of protect the device from water or moisture and other contaminants.

Regarding claims 7-9 and 12, the modified device as described above will have both the sound permeable barrier and fastener. As disclosed in claims 1, 2 and 13 above, using polytetrafluoroethylene as housing component is extremely well known in the art and would have been an obvious modification to the above modified device.

Regarding claims 10 and 11, both Hackett and Siebold clearly illustrated that the housing has at least one aperture. Also, whether to form an aperture or a grill would have been an

obvious design choice. Furthermore, a housing has a hole or grill is extremely well known in the art and would have been an obvious modification to the modified device mentioned above.

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Prior art references to Shields (U.S. Pat. No. 5,196,755), Lee (U.S. Pat. No. 5,218,634), Massa (U.S. Pat. No. 4,028,504), Rollins et al. (U.S. Pat. No. 4,931,765), Nakashima et al. (U.S. Pat. No. 4,700,177), Freadman (U.S. Pat. No. 5,550,921) and Bost (U.S. Pat. No. 4,413,198) are cited to show other piezoelectric transducers.

7. Any response to this action should be mailed to:

Commissioner of Patents and Trademarks

Washington, D.C. 20231

or faxed to:

(703) 872-9314, (for formal communications intended for entry)

Or:

(703) 872-9314, (for informal or draft communications, please label "PROPOSED" or "DRAFT")

Hand-delivered responses should be brought to Crystal Park II, 2121 Crystal Drive, Arlington. VA., Sixth Floor (Receptionist).

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Sihong Huang whose telephone number is (703) 305-3966.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jeffery Hofsass, can be reached on (703) 305-4717.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Customer Service Office whose telephone number is (703) 306-0377.

JEFFERY HOFSASS
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2600

S. Huang

December 14, 2001

INFORMATION DISCLOSURE CITATION

(Use several sheets if necessary)

JAN 16 2001 PATENT & TRADEMARK OFFICE

ATTY DOCKET NO.	SERIAL NO.
29[illegible]	09/667981
NAC CO.	
FILING: September 22, 2000	GROUP: 2632

RECEIVED JAN 22 2001 TC 2600 MAIL ROOM

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
SH		5,228,228	07/20/93	Meissner	43	17	
SH		5,726,626	03/10/98	Jabbour, et al.	340	407.1	
SH		5,825,280	10/20/98	Merendini, et al.	340	326	
SH		5,990,784	11/23/99	Burnett	340	384.7	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

EXAMINER	DATE CONSIDERED
S. Huang	12/9/01

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Notice of References Cited	Application/Control No. 09/667,981	Applicant(s)/Patent Under Reexamination BURNETT ET AL.	
	Examiner Sihong Huang	Art Unit 2632	Page 1 of 1

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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification	
	A	US-4420706	12-1983	Siebold et al.	310	324
	B	US-4042845	08-1977	Hackett	310	322
	C	US-5222050	06-1993	Marren et al.	367	163
	D	US-4987597	01-1991	Haertl	381	69
	E	US-6105214	08-2000	Press	24	389
	F	US-5196755	03-1993	Shields	310	324
	G	US-5218634	06-1993	Lee	379	375
	H	US-4028504	06-1977	Massa	179	146 R
	I	US-4931765	06-1990	Rollins et al.	340	407
	J	US-4700177	10-1987	Nakashima et al.	340	388
	K	US-5550921	08-1996	Freadman	381	24
	L	US-4413198	11-1983	Bost	310	324
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification	
	N						
	O						
	P						
	Q						
	R						
	S						
	T						

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

EXHIBIT D

United States Patent [19]

Haertl

[11] **Patent Number: 4,987,597**

[45] **Date of Patent: Jan. 22, 1991**

[54] **APPARATUS FOR CLOSING OPENINGS OF A HEATING AID OR AN EAR ADAPTOR FOR HEARING AIDS**

[75] Inventor: **Christof Haertl**, Neunkirchen, Fed. Rep. of Germany

[73] Assignee: **Siemens Aktiengesellschaft**, Berlin & Munich, Fed. Rep. of Germany

[21] Appl. No.: **251,857**

[22] Filed: **Oct. 3, 1988**

[30] **Foreign Application Priority Data**

Oct. 5, 1987 [DE] Fed. Rep. of Germany 8713369

[51] **Int. Cl.**[5] **H04R 25/00**

[52] **U.S. Cl.** **381/69**

[58] **Field of Search** 381/69, 68.6, 189; 181/129, 130, 135

[56] **References Cited**

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1270616	6/1968	Fed. Rep. of Germany	381/68.6
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8504765.1	7/1986	Fed. Rep. of Germany .	
3540579	5/1987	Fed. Rep. of Germany	381/6
2155276	9/1985	United Kingdom .	

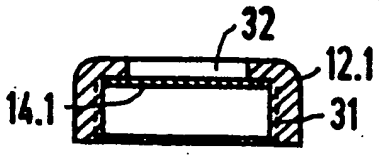
Primary Examiner—Forester W. Isen

Attorney, Agent, or Firm—Hill, Van Santen, Steadman & Simpson

[57] **ABSTRACT**

An apparatus for closing an opening of a hearing aid or an ear adaptor for a hearing aid, particularly openings such as sound entry openings, sound exit openings and aeration openings utilizes a micro-porous membrane of an anti-adhesive material which is introduced into the respective opening. Preferably, the membrane is poly-tetrafluoroethylene material.

4 Claims, 2 Drawing Sheets



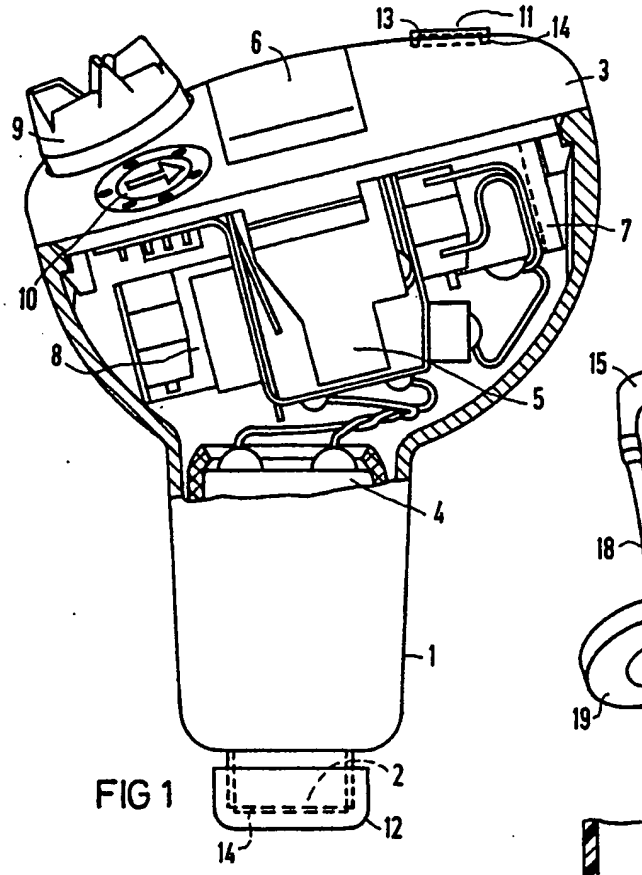


FIG 1

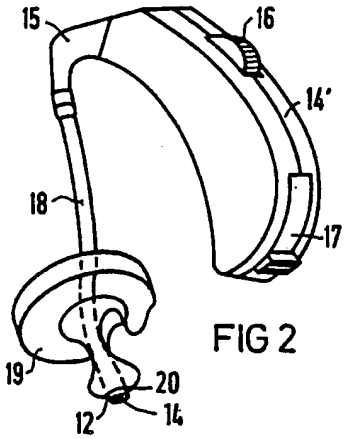


FIG 2

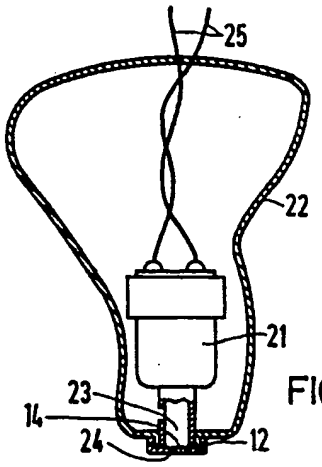


FIG 3

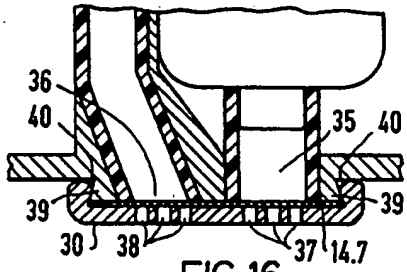


FIG 16

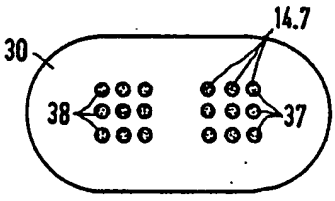


FIG 17

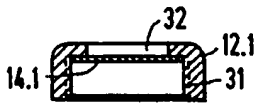


FIG 4

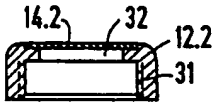


FIG 6

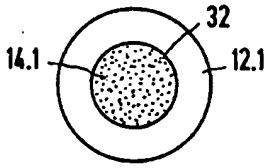


FIG 5

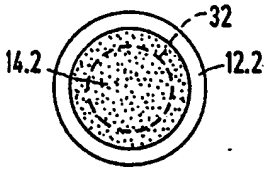


FIG 7

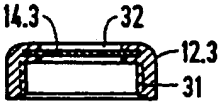


FIG 8

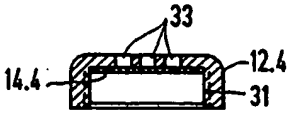


FIG 10

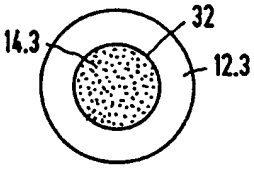


FIG 9

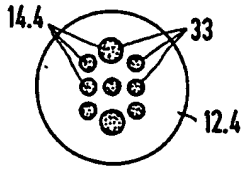


FIG 11

FIG 12

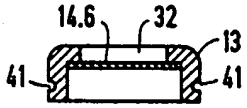


FIG 14

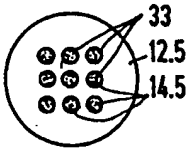


FIG 13

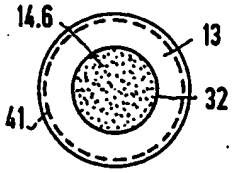


FIG 15

APPARATUS FOR CLOSING OPENINGS OF A HEATING AID OR AN EAR ADAPTOR FOR HEARING AIDS

BACKGROUND OF THE INVENTION

The present invention is directed to an apparatus for closing openings of a hearing aid or ear adaptor for hearing aids.

German Gebrauchsmuster No. 19 51 165 discloses an in-the-ear hearing aid, wherein a cylindrical member can be placed on a sound exit nozzle. The interior of this member has a chamber-like expansion of a bore in which a layer of porous, sound-permeable material is arranged. The sound proceeding from the earphone of the hearing aid into the bore can, thus, easily pass the layer of porous material. Earwax, or cerumen, that is secreted inside of the auditory channel or canal, however, cannot proceed into the inside of the hearing aid in the reverse direction, due to this porous layer of material.

Over and above the disclosures of the above-mentioned German Gebrauchsmuster, German Gebrauchsmusters No. 84 36 783 and 85 04 765 both disclose perforated caps that can be attached to a sound exit nozzle, either directly in an in-the-ear hearing aid or in an ear adaptor of a behind-the-ear hearing aid, which adaptor can then be introduced into the ear, for example by being pluggable or screwable therein. The perforated caps guarantee unimpeded sound exit. Earwax that is secreted in the auditory channel or canal is largely kept out by the openings, since relatively long creeping distances are present due to the formation of niches therein.

The solutions presented in the above-mentioned prior art for preventing earwax from creeping in, however, still is relatively undesirable. At the very least, the protective devices must be replaced or cleaned relatively frequently. Another disadvantage in these proposed solutions is that there is no protection against the penetration of moisture, particularly perspiration which will occur in the interior of the auditory channel and move in the direction of the earphone. Keeping out perspiration or sweat is of particular significance, especially given the in-the-ear hearing aids, because the path from the sound exit location to the earphone is relatively short and, as experience has taught, the extremely aggressive or salty sweat will quickly damage the earphone. However, such a protection is also needed, given behind-the-ear hearing aids, since damage to the earphone occurs over and over despite the relatively long path to the earphone.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an apparatus for closing an opening in an earphone for a hearing aid or the like, which is simpler to clean to remove contamination, such as earwax, and which simultaneously prevents moisture, particularly perspiration, from the auditory channel or ear canal from proceeding through the respective openings and into the hearing aid.

To accomplish these objects, the present invention is directed to an apparatus for closing openings for an ear adaptor for hearing aids, in particularly the openings for sound entry and/or sound exit, or for aeration. The apparatus comprises a micro-porous membrane of anti-adhesive or anti-adherent material, which is hydrophobic and is introducible into the respective opening.

A micro-porous membrane of an anti-adhesive or an anti-adhesive adherent material will prevent both the penetration of the earwax, because of the extremely small pores, and of moisture, particularly sweat, into the interior of the hearing aid because of the formation of the membrane of the anti-adhesive material or hydrophobic material. A hydrophobic material, namely, does not allow drops of sweat to become flat so that the drops can, likewise, not penetrate into the micro-pores. Due to the anti-adhering effect, however, the coating of earwax that has attached to the membrane can also be more easily removed than herebefore, for example with the assistance of ultrasonic cleaning.

A preferred development utilizes a micro-porous membrane which is composed of polytetrafluorethylene. A membrane of such a material is proven particularly suitable for the present purposes.

Other advantages and details of the invention will be readily apparent from the following description of the preferred embodiments with reference to the drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view with portions broken away for purposes of illustration of an in-the-ear hearing aid utilizing the present invention;

FIG. 2 is a perspective view of a behind-the-ear hearing aid having an ear adaptor which utilizes the present invention;

FIG. 3 is a cross sectional view with portions in elevational for purposes of illustration of a separate earphone for a behind-the-ear or pocket-type hearing aid utilizing the present invention;

FIGS 4–15 are various views of six modifications of a cap employing the present invention, with FIG. 4 being a cross sectional view of a first embodiment, FIG. 5 being a plan view of the first embodiment, FIG. 6 being a cross sectional view of a second embodiment, FIG. 7 being a plan view of the second embodiment, FIG. 8 being a cross sectional view of a third embodiment, FIG. 9 being a plan view of a third embodiment, FIG. 10 being a cross sectional view of a fourth embodiment, FIG. 11 being a plan view of the fourth embodiment, FIG. 12 being a cross sectional view of a fifth embodiment, FIG. 13 being a plan view of the fifth embodiment, FIG. 14 being a cross sectional view of a sixth embodiment, and FIG. 15 being a plan view of the sixth embodiment;

FIG. 16 is a cross sectional view of a portion of a hearing aid having a sound opening and an aeration opening simultaneously closed by a cap member; and

FIG. 17 is a plan view of the cap member of FIG. 16.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principles of the present invention are particularly useful for an in-the-ear hearing aid, illustrated in FIG. 1. The hearing aid has a housing 1 which has a sound exit nozzle 2 at one end and is covered at the opposite end by a end cover 3. An earphone 4 that has its output side connected to the sound exit nozzle 2 is partially shown in the cut-away housing of FIG. 1. The housing also has a battery compartment 5, which is illustrated without the battery being inserted therein and which compartment can be swivelled out of the hearing aid through a door or a hatch 6 in the end cover

3. The hearing aid housing, in addition, includes a microphone 7 and an amplifier electronics 8. On the cover 3 is a rotary knob 9 for setting the volume and a matching actuator 10.

The cover 3 has a sound entrance opening 11, which is covered by a cap 13 which, preferably, is constructed in accordance with the present invention. The nozzle 2 is illustrated as being covered or closed by a screwable cap 12, whereas the cap 13, as illustrated, is a snap-in-type cap, which is seated in the sound entry opening 11.

Both the caps 12 and 13 each have a micro-porous polytetrafluorethylene membrane 14, which membrane material is commercially available under the registered Trademark GORE-TEX. This membrane forms means for sealing the respective openings against earwax and sweat, which are both secreted in the auditory or ear canal. The membrane 14, respectively, however, is extremely transmissive for the sound respectively emerging or, respectively, entering the hearing aid. Various embodiments of the cap are shown in FIGS. 4–17 and shall be set forth in greater detail. The polytetraflourethylene membrane, which are sold by W. L. Gore & Associates, Inc., Newark, Del., U.S.A., are described, for example, in the perspectus "GORE-TEX PTFE Membranes and Laminates", 1986, W. L. Gore & Co. GmbH, D-8011 Putzbrunn and also in the European Published Patent Application No. 0160,473. GORE-TEX ® expanded PTFE is chemically inert and not affected by any common chemical. It has a low friction coefficient, functions within a wide temperature range, does not age, and is weather durable. It is also porous, air permeable, extremely strong, hydrophobic, and biocompatible.

The present invention is also particularly useful when embodied into a behind-the-ear hearing aid comprising a housing 14' (FIG. 2) that can be secured behind the ear with a carrying hook 15. The housing 14' has a rotary knob 16 for volume adjustment and also is illustrated as having a cover 17 for a battery compartment that can be swivelled out of the housing. The carrying hook 15 is connected to an ear adaptor 19 via a sound hose 18. A cap 12 of the present invention is, again, seated on its outer exit opening 20 of the adaptor 19.

The present invention is also useful in a separate earphone 21, which is mounted in the housing 22 (FIG. 3) that can be introduced into the auditory canal. The output of the dislocated or separate earphone 21 is connected to the sound exit nozzle 23, whose opening 24 is, in turn, covered by a cap 12 of the present invention. Electrical connecting lines 25 extend' from the housing of the earphone 21, either to a behind-the-ear hearing aid or to a hearing aid which is received in a pocket of the user.

Of the six embodiments of the caps illustrated in FIGS. 4–15, the first four embodiments of FIGS. 4–11 are adapted to be screwed onto the sound exit nozzle. The fifth embodiment of FIGS. 12 and 13 is arranged to be put in place or snapped on an undercut of a sound exit nozzle, such as disclosed by the two German Gebrauchsmusters No. 84 36 783 and 85 04 765. The sixth embodiment of FIGS. 14 and 15 shows an arrangement for a cap 13 for insertion into a sound entry opening for the microphone on a face cover 3 of a hearing aid of FIG. 1. A seventh embodiment of FIGS. 16 and 17 finally shows a corresponding arrangement wherein a cap 30 of the invention can be snapped onto an undercut and the cap 30 also, simultaneously, protects both a sound exit nozzle 35 and an aeration bore or opening 36.

As illustrated in FIGS. 4–11, each of the caps 12.1, 12.2, 12.3 and 12.4 have internal threads 31. The caps 12.1, 12.2, and 12.3 of FIGS. 4–9 also have a single central opening 32 on an end face of the cap. In addition, the cap 13 of FIGS. 14 and 15 also has a single central opening 32. The caps 12.4 and 12.5 of FIGS. 10–13 have a plurality of individual small openings 33 which are illustrated as being in two different patterns, with the pattern of openings of the cap 12.5 of FIG. 13 all having the same size openings, while the pattern of FIG. 11 for the cap 12.4 has two different size openings 33. The cap 12.5 of FIG. 12 does not have inside threads but is provided with a round annular bead 34 that will fit onto a respective undercut of the sound exit nozzle of the respective hearing aid or ear adaptor. In the embodiment illustrated in FIGS. 16 and 17, the sound exit nozzle 35 and an aeration bore 36 are surrounded by an annular bead or undercut 39. A cap 30, which has a group of holes 37 for covering the sound exit nozzle 35 and a group of holes 38 for the aeration pore 36, is provided with an annular bead 40 for engaging the undercut 39. The cap 13 of FIGS. 14 and 15 has an outer annular groove 41 which will engage in the opening edge upon introduction of the cap into a sound entry opening, such as the opening 11 of FIG. 1.

In each of the above arrangements or embodiments of the cap, a micro-porous polytetrafluorethylene membrane 14 obtainable under the Trademark "GORE-TEX" is utilized. Individual membranes are identified as 14.1–14.7 for each of the seven embodiments.

In the first embodiment of FIGS. 4 and 5, the membrane 14.1 is inserted or secured on the interior of the cap 12.1, as illustrated. The difference between the first embodiment and the second embodiment is that the membrane 14.2 of the second embodiment of FIGS. 6 and 7 is secured on the end face of the cap 12.2, as illustrated.

In the third embodiment of FIGS. 8 and 9, a membrane 14.3 is received in a groove in the opening 32, such as being molded in place in the cap 12.3. In the embodiments illustrated by the caps 12.4 and 12.5, the membrane 14.4 and 14.5, respectively, are secured on each of the caps in a fashion similar to the arrangement of the first embodiment of FIGS. 4 and 5. This is also true with the sixth embodiment which has a membrane 14.6 secured on the interior of the cap 13. In addition, the membrane 14.7 of the cap 30 is secured on the interior of the cap, as illustrated in FIG. 16.

As already previously described, the membrane 14 respectively provides a good sound transmissivity but, nonetheless, protects the respectively utilized hearing aid against the penetration both of earwax as well as moisture, particularly sweat, from the auditory canal. Since the sweat is kept away, sensitive component parts of the hearing aid are not exposed to the risk of damage due to corrosion or the like. As experience has shown, the utilized membrane material is water-tight up to 0.65 bar and can, thus, also be cleaned in an ultrasonic bath as needed without the sensitive electronic component parts of the hearing aid, particularly the earphone, being damaged. It is, thus, no longer required to completely replace the cap, as hereinbefore. The cerumen-contaminated cap can, thus, remain on the hearing aid. It is merely necessary to partially immerse the hearing aid or the ear adaptor that, of course, is made water-tight by the utilization of the membrane of the present invention into an ultrasound bath and to clean the membrane of the earwax. After cleaning the respective hear-

ing aid with the cap still screwed on it again available in a functional fashion and optimally cleaned without further manipulations.

Although various minor modifications may be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent granted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.

I claim:

1. An apparatus for closing openings in a housing of hearing aids and parts of hearing aids, said openings being selected from a group consisting of sound entry, sound exit and aeration openings, said apparatus comprising a cap being mounted on the housing to close the opening, said cap having an opening for the transmission of sound and air through the cap, said cap having means for preventing moisture, sweat and cerumen from passing through said opening in the cap, said means being a microporous membrane of a hydrophobic material extending across the opening of the cap, said material of the membrane being a microporous polytetraflourethylene.

2. An apparatus according to claim 1, wherein the membrane is an integral part of the cap.

3. An apparatus according to claim 1, wherein the membrane is at least partially molded into the cap.

4. An apparatus according to claim 1, wherein the membrane is separate from the cap and is placed between the cap and the opening of the housing before the cap is attached to the housing.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,987,597

DATED : January 22, 1991

INVENTOR(S) : Christof Haertl

It is certified that error appears in the above—identified patent and that said Letters Patent is hereby corrected as shown below:

ON TITLE PAGE:

Please correct the title to read:

—APPARATUS FOR CLOSING OPENINGS OF A HEARING AID OR AN EAR ADAPTOR FOR HEARING AIDS"—

Signed and Sealed this

Twenty-third Day of June, 1992

Attest:

Attesting Officer

DOUGLAS B. COMER

Acting Commissioner of Patents and Trademarks

[redacted]

"Duprez, Carol" <Carol.Duprez@bdk.com>

06/05/03 01:04 PM

To: "'hayes@nshn.com'" <hayes@nshn.com>

cc: "Mchugh, Cathy" <Cathy.Mchugh@bdk.com>, "Everett, Wallace" <Wallace.Everett@bdk.com>, "Shewmaker, Joe" <Joseph.Shewmaker@bdk.com>, "Schlappich, Jeff" <Jeff.Schlappich@bdk.com>

Subject: Orange & Black Photo Shoot, Jun 12 or 13

Dina:

Thanks for the update. Unfortunately, I will be out of the office the week of June 10th, when you arrive. Wallace Everett, however, will be available to meet you at security and show you where the product is being kept for this project.

Please feel free to call him if you should have any questions.

803-547-3648, office
803-242-8443, cell

Thank you,
Carol

-----Original Message-----
From: hayes@nshn.com [mailto:hayes@nshn.com]
Sent: Thursday, June 05, 2003 12:54 PM
To: Carol.Duprez@bdk.com
Cc: Cathy.Mchugh@bdk.com
Subject: BD v. HF - Ft. Mill production

Carol:

Thanks for helping with the production of everything in Ft. Mill. The people who need to see and/or take pictures of the product will most likely be at Ft. Mill on June 12th or 13th, starting at 11:00 am. I will come down to Ft. Mill and would like to see everything earlier that morning, say 9:30 am. I have spoken to a lawyer for Harbor Freight (named Alex Lasher) who will be attending the production and told him if they are unable to make the trip by the 13th, Black & Decker will pull the product on June 18th and return everything to inventory. So, the end for the orange & black is near. Once I hear a definite date for the production, I will let you know immediately.

Are there any procedures I need to know about about people coming into Ft. Mill? Who should I ask for when I arrive?

If you have any questions, please feel free to give me a call.
312-236-0733.

Thanks,
Dina

United States Patent [19]

Hackett

[11] **4,042,845**

[45] **Aug. 16, 1977**

[54] **TRANSDUCER ASSEMBLY AND METHOD FOR RADIATING AND DETECTING ENERGY OVER CONTROLLED BEAM WIDTH**

[75] Inventor: **Kenneth R. Hackett**, Boulder, Colo.

[73] Assignee: **Sontrix Division of Pittway Corporation**, Boulder, Colo.

[21] Appl. No.: **670,275**

[22] Filed: **Mar. 25, 1976**

[51] Int. Cl.² **H01L 41/04**

[52] U.S. Cl. **310/322**; 310/368

[58] Field of Search ..... 310/8, 8.2, 8.3, 8.5, 310/8.6, 9.1, 9.4; 340/8 R, 8 FT, 8 L, 9, 10, 11, 12, 13; 350/294; 343/837, 838, 840, 910, 914; 73/194 E; 179/110 A

[56] **References Cited**

U.S. PATENT DOCUMENTS

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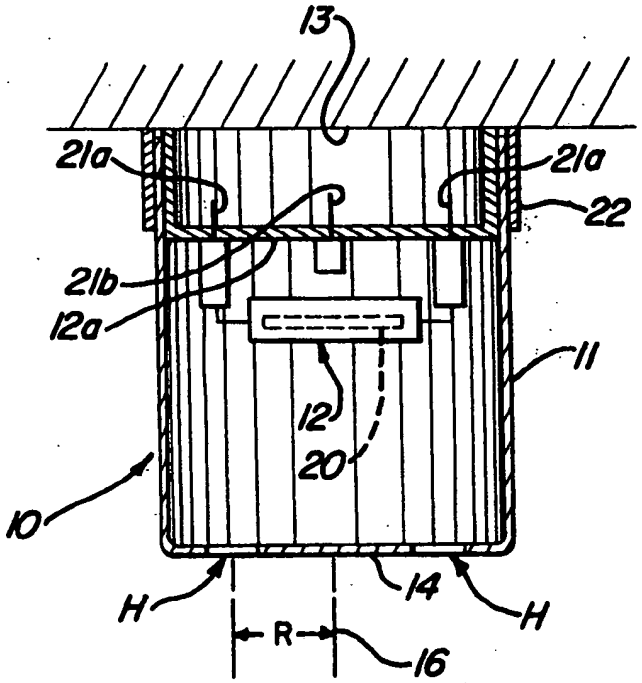
3,965,455	6/1976	Hurwitz	310/8.2 X

Primary Examiner—Mark O. Budd
Attorney, Agent, or Firm—Max L. Wymore

[57] **ABSTRACT**

A transducer assembly capable of radiating and detecting energy over a controlled beam width around a selected axis is formed by a piezoelectric element mounted in a cylindrical resonant cavity defined by a Helmholtz chamber. The resonant chamber has an energy emitting end wall positioned normal to the selected axis and is arranged to have a single aperture ring which emits energy symmetrically around the axis at a predetermined radial offset distance therefrom. The energy emitted from the chamber through the end wall sums to form along and around the selected axis a beam-like pattern of controlled width, the beam width being controllable as a function of the offset distance and the energy wavelength. In one embodiment, circular apertures which operate to emit spherical radiation patterns are formed in the chamber end wall. In another embodiment, an annular aperture is formed in the chamber end wall concentric with the selected axis.

29 Claims, 6 Drawing Figures



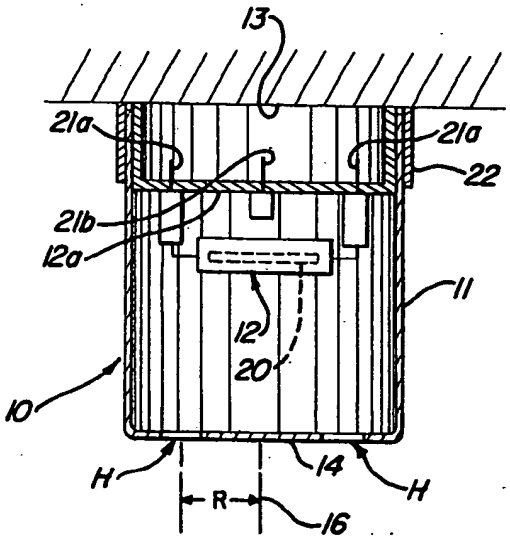


Fig _ 1

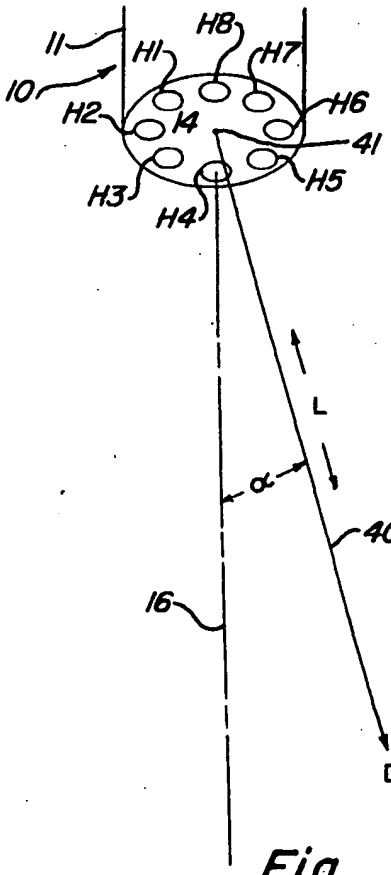


Fig _ 2

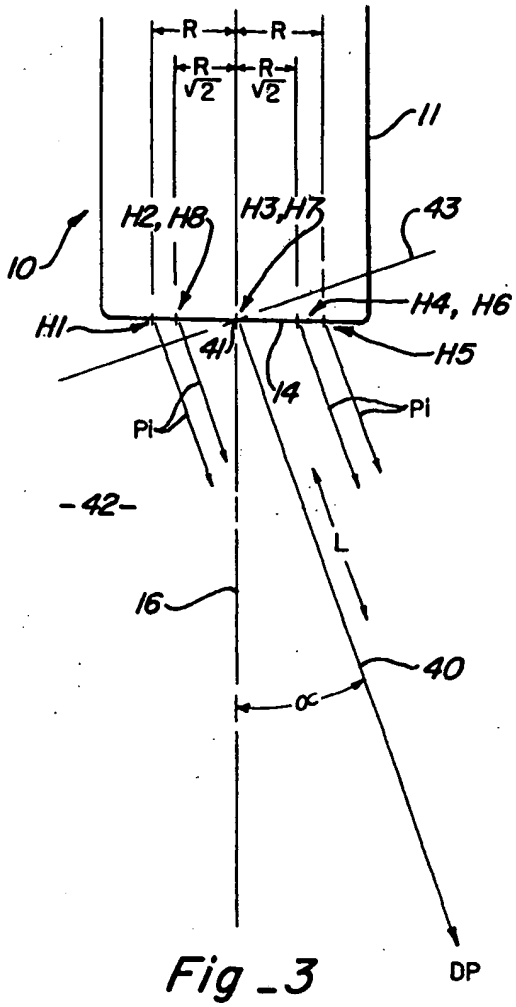


Fig _ 3

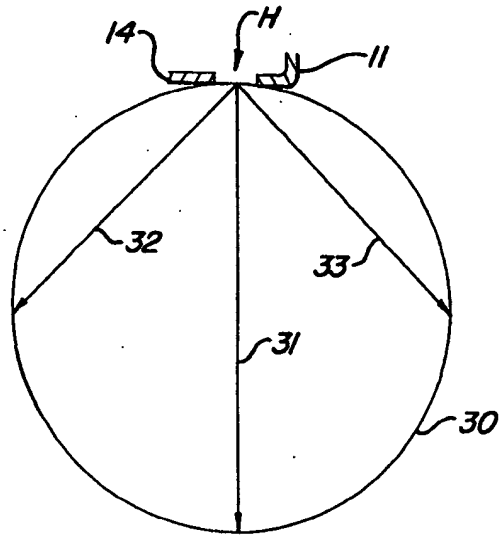


Fig _ 4

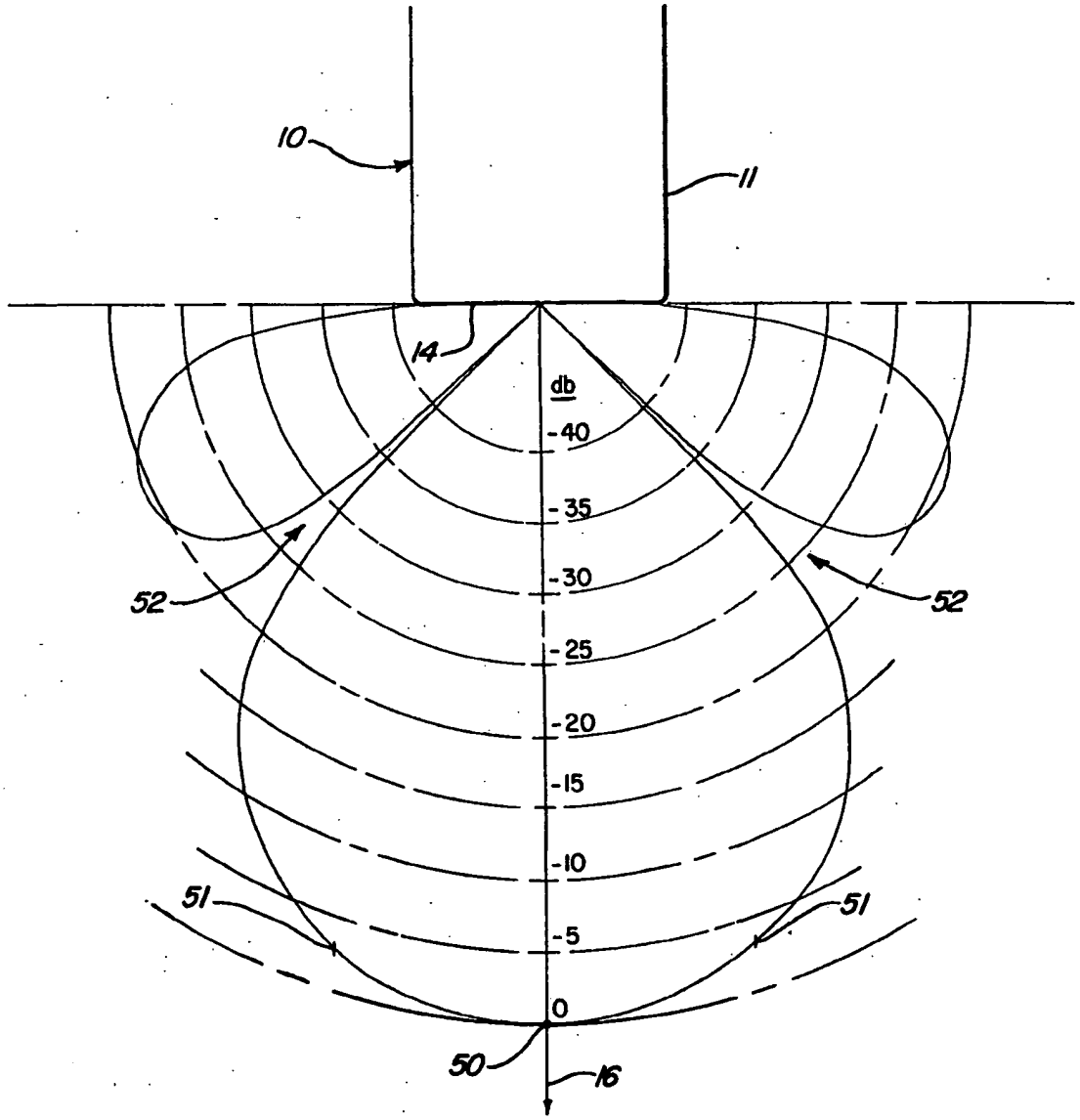


Fig_5

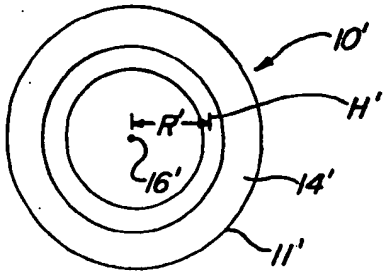


Fig_6

TRANSDUCER ASSEMBLY AND METHOD FOR RADIATING AND DETECTING ENERGY OVER CONTROLLED BEAM WIDTH

BACKGROUND OF THE INVENTION

The present invention relates to transducer assemblies, and methods for radiating and detecting energy over a controlled beam width.

Transducer assemblies employing piezoelectric elements which radiate and sense acoustical energy at ultrasonic frequencies are commonly employed in detection systems to monitor areas to be protected. Due to differences in the shapes and sizes of individual areas to be monitored, it is desirable to be able to control the beam width over which energy can be radiated and detected by such transducer assemblies. Heretofore, it has generally been necessary to employ external reflectors or focusing surfaces in order to achieve such beam width control. An example of such a transducer assembly employing external reflecting surfaces is illustrated in assignee's copending U.S. patent application Ser. No. 471,280, filed May 20, 1974, entitled "PIEZOELECTRIC TRANSDUCER ASSEMBLY AND METHOD FOR GENERATING A CONE SHAPED RADIATION PATTERN."

SUMMARY OF THE INVENTION

It is, accordingly, an object of the present invention to provide an improved transducer assembly suitable for use in ultrasonic detection systems capable of radiating and/or detecting acoustical energy over a controlled beam width without the use of external reflectors or focusing surfaces.

It is also an object of the present invention to provide an improved method for radiating and/or detecting acoustical energy over a controlled beam width around and along a selected axis.

It is further an object of the present invention to provide an improved transducer assembly characterized by employing a resonant chamber to achieve enhanced acoustical output and detection sensitivity.

It is additionally an object of the present invention to provide an improved method for radiating and/or detecting acoustical energy characterized by being of enhanced efficiency.

In accomplishing these and other objects, a transducer assembly capable of radiating and detecting energy over a controlled beam width around a selected axis is formed by a piezoelectric element mounted in a cylindrical resonant cavity defined by a Helmholtz chamber. The resonant chamber has an energy emitting end wall structure positioned normal to the selected axis and is arranged to have a single aperture ring which emits energy symmetrically around the axis at a predetermined radial offset distance therefrom. The energy emitted from the chamber through the end wall sums to form along and around the selected axis a beam-like pattern of controlled width, the beam width being controllable as a function of the offset distance and the energy wavelength.

In one embodiment, circular apertures or openings which operate to emit spherical radiation patterns are formed in the chamber end wall to define the single aperture ring. In another embodiment, the single aperture ring is provided by an annular aperture or opening formed in the chamber end wall concentric with the selected axis.

Additional objects reside in the specific construction of the exemplary embodiments of a transducer assembly hereinafter described and their methods of operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a transducer assembly according to the present invention;

FIG. 2 is a perspective view of the energy emitting end of the assembly of FIG. 1;

FIG. 3 is a side view of the assembly of FIG. 1;

FIG. 4 is a cross-sectonal view of the spherical radiation pattern emitted by a circular aperture in the energy emitting end wall of the assembly of FIG. 1;

FIG. 5 is a plot of the energy pattern generated by one specific transducer assembly of the type shown in FIG. 1; and,

FIG. 6 is a plan view of the energy emitting end wall portion of another transducer assembly according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings in more detail, there is shown in FIGS. 1—3 a transducer assembly generally identified by the numeral 10. The assembly 10 is made up of a resonant chamber 11 and a transducer 12. The transducer 12 employed may be conventional in construction, as hereinafter discussed, and accordingly, its details are not shown in the drawings.

The chamber 11 is shown mounted on structure 13 and defines a resonant cavity, being of the type commonly referred to as a Helmholtz chamber. As shown in FIG. 1, the base end of the chamber 11 is completely closed by the support 12*a* supporting the transducer 12. The other end of the chamber 11, which may be referred to as the top or energy emitting end, is defined by the chamber end wall 14. As shown in FIGS. 2 and 3, the end wall 14 has a plurality of circular apertures or holes H formed therein in planar alignment which define a single aperture ring. Eight similar openings H are shown, which are designated for purposes of discussion H1–H8. The apertures H are equally spaced apart circumferentially around the longitudinal axis 16 of the chamber 11 in a plane normal thereto. The centerpoints of the apertures H define a circle of radius R concentric with the chamber axis 16. Hence, the centerpoint of each aperture H is offset from the axis 16 the radial distance R.

The chamber end walls defined by the support 12*a* and wall 14 are each positioned normal to the chamber longitudinal axis 16. The cylindrical side wall of the chamber 11 is disposed parallel with the axis 16.

Mounted within the chamber 11 to extend symmetrically and perpendicularly across its longitudinal axis 16 is the transducer 12. The transducer 12 is mounted upon support 12*a* in a conventional manner and includes a piezoelectric element 20 (shown representatively in dashed lines).

Piezoelectricity is pressure electricity and piezoelectric behavior is the characteristic of materials to deform upon the application of electrical signals or conversely to develop electricity whenever deformed by the application of pressure. Materials exhibiting piezoelectric behavior are naturally occurring or may be man made.

The piezoelectric element employed in the transducer 20 is a flat plate-like bender type, such as the bender type of piezoelectric element made by Clevite Corporation under the name BIMORPH. Further description of

the operation of this type of piezoelectric element is given in assignee's aforementioned copending U.S. patent application Ser. No. 471,280, filed May 20, 1974, and is hereby incorporated by reference.

Such a piezoelectric element 20 is generally rectangular in shape and has a circular node about which it flexes or bends. The element edge portions outside of the node always move in the direction opposite to the direction of movement of the element center portion within the node.

The piezoelectric element 20 incorporated in the transducer 12 has a selected, preferably ultrasonic, natural resonant frequency and is mounted in the transducer 12 for free vibration about its node. Included in the transducer 12 is structure which causes the compression and rarefaction waves generated on opposite sides of the node of the piezoelectric element 20 to be phase shifted so as to combine through constructive interference and reinforce each other. Additionally, the piezoelectric element is held in the transducer 12 appropriately spaced from the adjacent surface of support 12*a* so that sound waves generated on opposite sides of the plane of the piezoelectric element 20 are reflected to constructively interfere and hence reinforce each other.

The transducer 12 includes electrical contacts and terminals 21*a* and 21*b* through which electrical signals may be picked off or applied to the opposite faces of the piezoelectric element 20. One suitable manner in which the piezoelectric element 20 may be mounted and held in the transducer 12 is disclosed in U.S. Pat. No. 3,704,385 issued on Nov. 28, 1972 to Schweitzer et al.

When the piezoelectric element 20 is electrically excited at its natural resonant frequency, the transducer 12 operates to generate in the chamber 11*a* spherical radiation pattern. The natural resonant frequency of the element 20 is here assumed to be an ultrasonic resonant frequency, and the wavelength of this resonant frequency is hereinafter referred to as λ.

The Helmholtz chamber 11 is axially adjustable with respect to the end wall defined by the transducer support 12*a* and is adjusted to define a resonant cavity of appropriate length to have a resonant frequency corresponding to the resonant frequency of the piezoelectric element 20. As a consequence, the acoustical output of the transducer 12 is amplified by the resonant action of the Helmholtz chamber 11 and the chamber 11 functions to improve the transducer to air transfer efficiency. Once the length of the chamber 11 is appropriately adjusted, the chamber 11 is retained in position with respect to the support 12*a* by clamping ring 22.

The Helmholtz chamber 11 operates to amplify and convert the spherical radiation pattern of ultrasonic energy generated by the transducer 12 along axis 16 into a plurality of substantially spherical radiation patterns 30 which are outputted by the apertures H.

FIG. 4 illustrates a cross-sectional view of the spherical radiation pattern 30 emitted by one of the holes H. Sound vectors 31, 32 and 33 are there identified. The vector 31 represents full power and lies parallel to the longitudinal axis 16 of the chamber 11 at the radial offset distance R therefrom. The sound vectors 32 and 33 represent one-half power and lie at 45° angles to the full power vector 31.

It is noted that regardless of where an individual circular aperture is located in the chamber end wall 14 substantially the same output will be emitted therefrom. That is to say, a single circular aperture or hole in the center of the chamber end wall 14 would produce approximately the same output as a similar single hole near the outer periphery of the end wall 14.

Two specific advantages, however, are obtained by utilizing a plurality of apertures in the outer peripheral portion of the end wall 14 instead of employing a single center aperture. One advantage is that by increasing the number of apertures the output, and likewise pickup sensitivity, of the transducer assembly 10 is increased. Secondly, as discussed hereinafter, the advantage is obtained that the beam width of the energy pattern radiated by the transducer assembly can be selectively controlled as a function of the positioning of the apertures H. With a single center aperture, the beam width of the energy pattern radiated is not controllable, except by the use of external reflectors, and would be a spherical radiation pattern like that shown in FIG. 4.

In operation of the transducer assembly 10, the total sound pressure PT radiated thereby to any distant point is equal to the vector sum at the distant point of the individual ultrasonic pressure waves *Pi* of frequency *f* and wavelength λ received from the apertures H1–H8. Total sound pressure *PT* at the distant point may be expressed by the following equation:

$$PT = \sum_{i=H1}^{i=H8} Pi \qquad \text{Equation (1)}$$

In FIGS. 2 and 3, a vector 40 is shown drawn from the center point 41 of the chamber energy emitting end wall 14 to an exemplary distant point DP. The distant point DP is located distance L from the center point 41, and the distance L is assumed to be significantly larger than the offset distance R of the centerpoints of the apertures H from the axis 16. Hence, the path of the individual pressure waves P*i* from each of the apertures H to the distant point DP can be considered to be substantially parallel to the vector 40, as shown in FIG. 3.

The angle between vector 40 and the axis 16 is designated alpha (α). For convenience, the centerpoints of the apertures H1 and H5 are assumed to lie in the plane 42 defined by the exemplary distant point DP and chamber axis 16. In FIG. 3, the plane of the paper corresponds to the plane 42.

The pressure wave *p* emitted by any one of the apertures H towards the distant point DP, i.e., along a path parallel to the vector 40, may be expressed as the following rotating phasor:

$$p = (P \cos \alpha) e^{j2\pi ft} \qquad \text{Equation (2)}$$

where $P \cos \alpha$ represents the magnitude at the aperture of the sound pressure wave emitted along the selected path; and $e^{j2\pi ft}$ represents the phase of the pressure wave.

Attenuation, due to distance, absorption and other factors, occurs to the pressure wave emitted from the aperture H as it travels therefrom to the point DP. It has been found that the attenuation factor K can be considered substantially the same for each of the apertures H. Thus, the magnitude of the pressure wave Pi reaching the point DP from any of the apertures H can be expressed as $K(P \cos \alpha)$.

The phase of the pressure wave Pi reaching the point DP from any of the apertures H is a function of the transit time from the specific aperture to the point DP, and hence is a function of the distance the pressure wave must travel to the point DP divided by its wave-

length λ. The phase of the pressure wave reaching the point DP from any one of the apertures H can be expressed as $e^{j2\pi(ft + L/\lambda + S/\lambda)}$, where the L/λ term is the phase shift due to the transit time required to traverse the distance L and the S/λ term is the phase shift due to the angle α, which angle causes an additional travel distance S to be associated with specific apertures.

Thus, the pressure wave Pi reaching the point DP from any of the apertures H is expressed by the following equation:

$$Pi = K(P\cos\alpha)e^{j2\pi(ft + L/\lambda + S/\lambda)} \quad \text{Equation (3)}$$

Equation (3) can be rewritten as follows:

$$Pi = [KPe^{j2\pi(ft + L/\lambda)}][e^{j2\pi S/\lambda}]\cos\alpha \quad \text{Equation (4)}$$

Examining Equation (4), the term $[KPe^{j2\pi(ft + L/\lambda)}]$ is steady state and the same for all apertures H1–H8. Therefore, let $KPe^{j2\pi(ft + L/\lambda)} = U$. Equation (4) can now be written as follows:

$$Pi = Ue^{j2\pi S/\lambda}\cos\alpha \quad \text{Equation (5)}$$

In Equation (5), the S represents the distance along a path parallel to the vector 40 in addition to the distance L which a pressure wave Pi has to travel from a specific aperture H to reach the point DP. The distance S is positive if the specific aperture is located greater than the distance L from the point DP; is negative if the aperture is located closer than the distance L to the point DP; and, is zero if the aperture is located the exact distance L from the point DP.

Referring to FIG. 3, a line 43 is shown drawn through centerpoint 41 perpendicular to the vector 40. By referring to the location of the centerpoints of the apertures H1–H8 relative to the position of the line 43, it can be seen that: the centerpoints of apertures H1, H2, and H8 are located a distance greater than L from the point DP; the centerpoints of the apertures H3 and H7 are located the distance L from the point DP; and, the centerpoints of the apertures H4, H5 and H6 are located closer than the distance L to the point DP. Listed below is the distance S calculated for each of the apertures H1–H8.

Aperture	Distances
$H1$	$R\sin\alpha$
$H2$	$R/\sqrt{2}\sin\alpha$
$H3$	0
$H4$	$-R/\sqrt{2}\sin\alpha$
$H5$	$-R\sin\alpha$
$H6$	$-R/\sqrt{2}\sin\alpha$
$H7$	0
$H8$	$R/\sqrt{2}\sin\alpha$

Equation (5), which gives the individual pressure wave Pi arriving at point DP from any aperture H, may now be solved for each of the apertures. Tabulated below are the results.

Aperture	Pi
$H1$	$PH1 = Ue^{j\frac{2\pi R\sin\alpha}{\lambda}\cos\alpha}$
$H2$	$PH2 = Ue^{j\frac{2\pi R\sin\alpha}{\sqrt{2}\lambda}\cos\alpha}$
$H3$	$PH3 = U\cos\alpha$
$H4$	$PH4 = Ue^{-j\frac{2\pi R\sin\alpha}{\sqrt{2}\lambda}\cos\alpha}$
$H5$	$PH5 = Ue^{-j\frac{2\pi R\sin\alpha}{\lambda}\cos\alpha}$
$H6$	$PH6 = Ue^{-j\frac{2\pi R\sin\alpha}{\sqrt{2}\lambda}\cos\alpha}$
$H7$	$PH7 = U\cos\alpha$
$H8$	$PH8 = Ue^{\frac{2\pi R\sin\alpha}{\sqrt{2}\lambda}\cos\alpha}$

Letting gamma (γ) equal

$$\frac{2\pi R\sin\alpha}{\lambda},$$

the total sound pressure PT in accordance with Equation (1) may be calculated as follows:

$$PT = PH1 + PH2 + PH3 + PH4 + PH5 + PH6 + PH7 + PH8 \quad \text{Equation (6)}$$

$$PT = U[e^{j\gamma} + e^{j\gamma/\sqrt{2}} + 1 + e^{-j\gamma/\sqrt{2}} + e^{-j\gamma} + e^{-j\gamma/\sqrt{2}} + 1 + e^{j\gamma/\sqrt{2}}]\cos\alpha \quad \text{Equation (7)}$$

$$PT = U[e^{j\gamma} + e^{-j\gamma} + 2 + 2e^{j\gamma/\sqrt{2}} + 2e^{-j\gamma/\sqrt{2}}]\cos\alpha \quad \text{Equation (8)}$$

In Equation (8), the following substitutions may be made:

$$2\cos\gamma = e^{j\gamma} + e^{-j\gamma} \quad \text{Equation (9)}$$

$$4\cos\gamma/\sqrt{2} = 2e^{j\gamma/\sqrt{2}} + 2e^{-j\gamma/\sqrt{2}} \quad \text{Equation (10)}$$

Making these substitutions in Equation (8) yield:

$$PT = U[2\cos\gamma + 4\cos\gamma/2 + 2]\cos\alpha \quad \text{Equation (11)}$$

Equation (11) may be used to calculate the resultant pressure PT produced by the transducer assembly 10 at any specific distance point. Also, Equation (11) can be used to plot the energy pattern radiated by the transducer assembly 10.

FIG. 5 shows a plot of the symmetrical energy pattern radiated by a specific transducer assembly constructed like the transducer assembly 10. The specific transducer assembly is constructed to generate sound pressure waves at the ultrasonic resonant frequency of 26.5 KHZ, i.e., a wavelength of 0.5 inches, and has its eight sound emitting apertures offset a radial distance R of 0.2625 inches from the longitudinal axis 16 of the transducer assembly.

Referring to FIG. 5, the circular lines on the energy plot indicate the relative level of the resultant output PT in decibels, the decibel level being indicated at the point the circles cross the axis 16. By using Equation (11) or from the plot shown in FIG. 5, it can be determined that: maximum signal occurs when α is zero, i.e., at point 50 on the axis 16; half power points 51 occur

when α equals 18.46°; and a null 52 occurs at α equals 46.8°.

It is noted that if the specific transducer assembly 10 constructed (whose energy plot is shown in FIG. 5) is used in the detection mode, its sensitivity to acoustical energy is the same as the output pattern plotted in FIG. 5.

Referring to FIG. 6, an alternate embodiment of transducer assembly 10 according to the present invention is there shown. The construction and operation of the assembly 10' correspond, except for the hereinafter noted exception, to that of the transducer assembly 10. Accordingly, corresponding parts of the transducer assembly 10' are given the same designation with a prime added as used in connection with the assembly 10.

The transducer assembly 10' has the single aperture ring formed by an annular energy emitting aperture H', instead of a series of circular apertures. The annular aperture H' defines a circle at a radius R around and concentric with the longitudinal axis 16' of the resonant chamber 11'. In operation in the active radiating mode, the assembly 10' emits energy through the annular aperture 10' symmetrically around the transducer longitudinal axis 16' at the predetermined radial offset distance R therefrom. The emitted energy sums in a manner like that above described in connection with the transducer assembly 10, to form along and around the selected axis 16' a symmetrical beam-like pattern of controlled width, the beam width being controllable as a function of the offset distance R and the wavelength λ of the emitted energy.

It is noted that the size of the apertures H and H' are not critical, but preferably are not larger than $\lambda/2$. Making the apertures larger than $\lambda/2$ would include out of phase components in the energy radiated from the apertures and tend to decrease the output.

It is further noted that while no specific structure is shown in FIG. 6 for supporting the central portion of the end wall 14', such would be included therein. Such support structure could traverse the opening H' and interrupt somewhat its continuity. Nevertheless, the opening H' would be a substantially continuous annular opening.

Thus, there is provided improved transducer assembly and method for radiating and detecting acoustical energy having the advantages of increased efficiency and controlled beam width without the use reflecting and focusing surfaces.

Although, the transducer assemblies herein shown and described are what are conceived to be the most practical and preferred embodiments of the invention, it is recognized that various modifications can be made therein in making a transducer assembly in accordance with the spirit of the invention which operates in an equivalent manner to obtain an equivalent result.

What is claimed is:

1. A transducer assembly for generating and/or detecting acoustical energy at a predetermined frequency over a controlled beam width around a selected axis, said assembly comprising:

a hollow, closed cylindrical resonant chamber having planar end walls and a predetermined resonant frequency, said chamber having a longitudinal axis defined by the center axis of the cylinder which it forms, said longitudinal axis defining said selected axis and said planar end walls being disposed normal to said selected axis, one of said planar end walls having a single aperture ring formed therein through which acoustical energy can be emitted out from and into said chamber, said single aperture ring being symmetrically disposed around said selected axis at a given radial offset distance therefrom; and

transducer means mounted within said chamber for generating therein along said selected axis a spherical radiation pattern of acoustical energy at said predetermined frequency.

2. The invention defined in claim 1, wherein said single aperture ring is a plurality of substantially circular openings formed in said planar end wall, said openings being substantially equally spaced apart circumferentially around said selected axis at said given offset distance therefrom.

3. The invention defined in claim 1, wherein said single aperture ring is a substantially continuous annular opening formed in said planar end wall around and concentric with said selected axis at said given offset distance therefrom.

4. The invention defined in claim 1, wherein:

said predetermined frequency is an ultrasonic frequency; and,

said transducer means includes a piezoelectric element which resonates at said predetermined ultrasonic frequency.

5. The invention defined in claim 1, wherein:

said predetermined frequency is an ultrasonic frequency; and,

said transducer means is positioned substantially symmetrically across the longitudinal axis of said resonant chamber and includes a piezoelectric element which resonates at said predetermined ultrasonic frequency.

6. The invention defined in claim 5, wherein said piezoelectric element is of the flat plate-like bender type.

7. The invention defined in claim 5, wherein said single aperture ring is a plurality of substantially circular openings formed in said planar end wall, said openings being substantially equally spaced apart circumferentially around said selected axis at said given offset distance therefrom.

8. The invention defined in claim 5, wherein said single aperture ring is a substantially continuous annular opening formed in said planar end wall around and concentric with said selected axis at said given offset distance therefrom.

9. The invention defined in claim 7, wherein said piezoelectric element is of the flat plate-like bender type.

10. The invention defined in claim 8, wherein said piezoelectric element is of the flat plate-like bender type.

11. The method of generating a pattern of acoustical energy at a predetermined frequency over a controlled beam width around a selected axis, comprising:

generating along said selected axis a spherical radiation pattern of acoustical energy at said predetermined frequency; and,

emitting said spherical radiation pattern of acoustical energy through a single aperture ring formed in wall structure, the wall structure extending across and normal to said selected axis, the single aperture ring being formed in a symmetrical configuration relative to and around said selected axis at a given radial offset distance from said selected axis.

12. The method of claim 11, wherein said spherical radiation pattern of acoustical energy is generated in a resonant chamber.

13. The method of claim 12, wherein the resonant chamber is a cylindrical resonant chamber.

14. The method of claim 11, wherein the single aperture ring is a plurality of substantially circular openings formed in the wall structure, the openings being substantially equally spaced apart circumferentially around said selected axis at said given offset distance therefrom.

15. The method of claim 11, wherein the single aperture ring is a substantially continuous annular opening formed in the wall structure around and concentric with said selected axis at said given offset distance therefrom.

16. The method of claim 12, wherein the single aperture ring is a plurality of substantially circular openings formed in the wall structure, the openings being substantially equally spaced apart circumferentially around said selected axis at said given offset distance therefrom.

17. The method of claim 12, wherein the single aperture ring is a substantially continuous annular opening formed in the wall structure around and concentric with said selected axis at said given offset distance therefrom.

18. The method of claim 16, wherein the resonant chamber is a cylindrical resonant chamber.

19. The method of claim 17, wherein the resonant chamber is a cylindrical resonant chamber.

20. The method of claim 11, wherein said predetermined frequency is ultrasonic.

21. The method of claim 12, wherein said predetermined frequency is ultrasonic.

22. The method of claim 18, wherein said predetermined frequency is ultrasonic.

23. The method of claim 19, wherein the predetermined frequency is ultrasonic.

24. The method of detecting acoustical energy at a predetermined frequency over a controlled beam width around a selected axis, comprising:

positioning a hollow, closed cylindrical resonant chamber along said selected axis with the longitudinal axis of the cylindrical resonant chamber coincident with said selected axis, the resonant chamber being operable to amplify acoustical energy at said predetermined frequency and having piezoelectric transducer means therein operable to generate and hence sense within said resonant chamber along said selected axis a spherical radiation pattern of acoustical energy at said predetermined frequency; and

emitting acoustical energy into the resonant chamber through a single aperture ring formed in end wall structure of the resonant chamber normal to said selected axis, the single aperture ring being formed in a symmetrical configuration relative to and around said selected axis at a given radial offset distance from said selected axis.

25. The method of claim 24, wherein the single aperture ring is a plurality of substantially circular openings formed in the wall structure, the openings being substantially equally spaced apart circumferentially around said selected axis at said given offset distance therefrom.

26. The method of claim 24, wherein the single aperture ring is a substantially continuous annular opening formed in the wall structure around and concentric with said selected axis at said given offset distance therefrom.

27. The method of claim 24, wherein said predetermined resonant frequency is ultrasonic.

28. The method of claim 25, wherein said predetermined resonant frequency is ultrasonic.

29. The method of claim 26, wherein said predetermined resonant frequency is ultrasonic.

* * * * *

US005222050A

United States Patent [19]

Marren et al.

[11] Patent Number: 5,222,050

[45] Date of Patent: Jun. 22, 1993

[54] **WATER-RESISTANT TRANSDUCER HOUSING WITH HYDROPHOBIC VENT**

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[73] Assignee: **Knowles Electronics, Inc.**, Itasca, Ill.

[21] Appl. No.: **900,662**

[22] Filed: **Jun. 19, 1992**

[51] **Int. Cl.**[5] **H04R 17/00**

[52] **U.S. Cl.** **367/163**; 367/167; 367/172; 367/174; 367/132; 181/132; 181/135; 381/154; 381/187

[58] **Field of Search** 181/129, 132, 135, 137, 181/149, 198; 367/131, 132, 163, 167, 172, 174, 910; 405/193; 381/154, 187, 188, 189

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Primary Examiner—J. Woodrow Eldred

Attorney, Agent, or Firm—Wallenstein, Wagner & Harris, Ltd.

[57] **ABSTRACT**

An immersion-resistant housing adapted to receive a vibratable diaphragm spanning the interior of the housing to divide the housing into first and second chambers includes a first port communicating between the first chamber and the exterior environment. The first port is configured as a tubulation. A second port communicates between the second chamber and the external environment. The tubulation has sufficiently small diameter that water entering therein moves essentially as a piston without breakup. The tubulation is configured to have a volume at least equal to that of the first chamber, and a hydrostatic head of about 32 feet of water is necessary before water can be forced into the first chamber. In the preferred embodiment the diaphragm completely seals the housing against direct communication between the two chambers. Pressure equalization across the diaphragm under conditions of varying atmospheric pressure is achieved by a selective sealing system permitting passage of air through the second port while preventing the passage of water therethrough at pressures up to at least three and preferably ten meters of hydrostatic head.

31 Claims, 2 Drawing Sheets

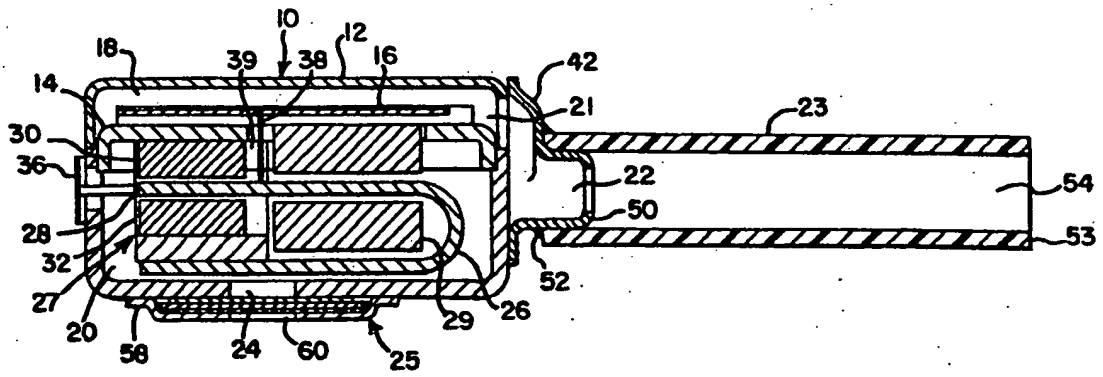


FIG. 1

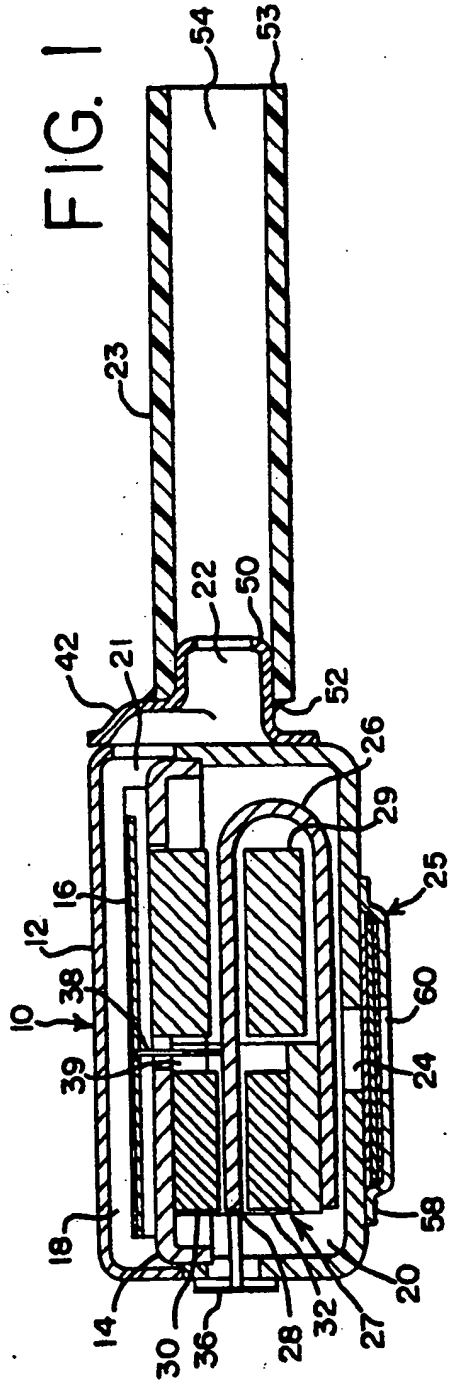


FIG. 2

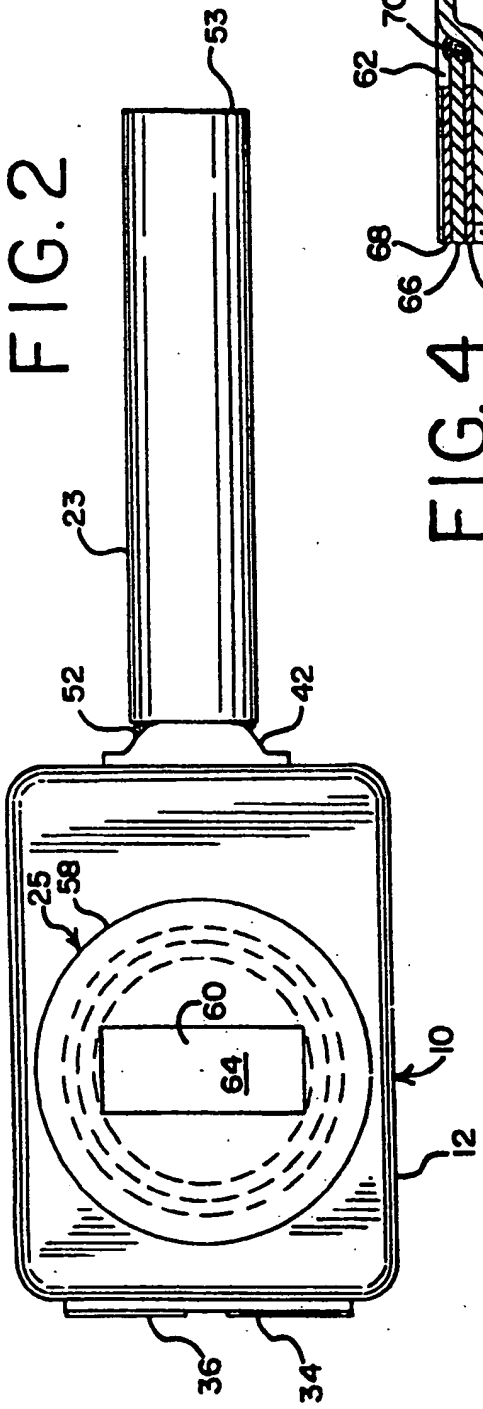
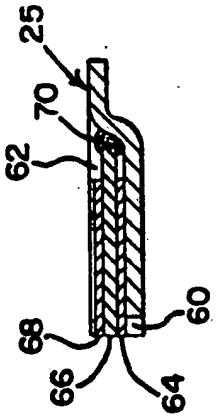


FIG. 4



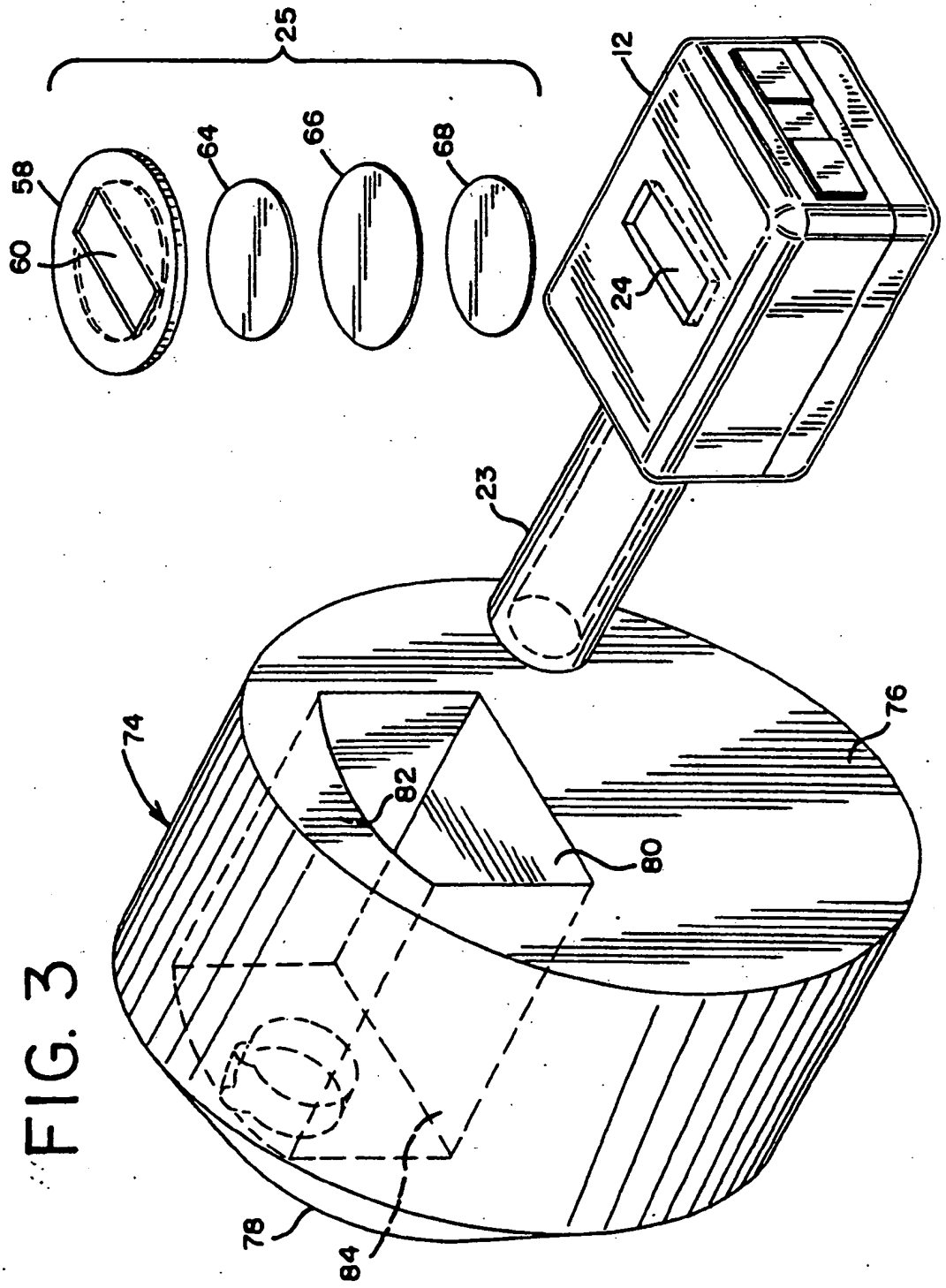


FIG. 3

WATER-RESISTANT TRANSDUCER HOUSING WITH HYDROPHOBIC VENT

TECHNICAL FIELD OF THE INVENTION

The technical field of the invention is water-immersible electrosonic transducers.

BACKGROUND PRIOR ART

In helicopter borne air-sea rescue operations, radio-equipped divers are frequently dropped into the water from a substantial height. For a diver to reach a depth of 3 meters below the surface of the water upon such an entry is a possible experience, and in exceptional cases depths of as much as 10 meters may be momentarily attained.

It is desirable that the earphone of the two-way radio communication unit be configured to be worn in the ear. Furthermore, any such earphone must be able to withstand at least momentary immersion, preferably to as much as 10 meters, and upon returning to the surface be immediately in serviceable condition. This requires that an in-the-ear earphone must be sealed against water entry, and must also provide adequate signal output once the earphone is no longer immersed. This requires some form of water entry barrier system to the interior of the earphone.

One approach to forming a barrier which is water-impermeable but sound permeable is disclosed in U.S. Pat. No. 4,987,597, issued to Haertl, Jan. 22, 1991. As disclosed therein, a membrane seal made of porous hydrophobic polytetrafluoroethylene is disposed to sealingly cover the output conduit of an in-the-ear hearing aid. The purpose of the membrane is to allow sound to pass through, but to reject any entry of perspiration. The hydrophobic property of the membrane prevents water from entering the pores of the structure; however, in the absence of water blockage, the membrane can successfully pass sound.

Attempts were made to employ this principle to a deep-immersion microphone. Similar membranes were affixed to the outlet conduits of in-the-ear hearing aid transducers. It was soon discovered that such a membrane, when made sufficiently stiff to successfully resist water at 10 meter immersion pressures, introduced an unacceptable degree of sound absorption. Alternative approaches using various forms of sealing diaphragms, either alone or in combination, resulted in structures that were either physically too large or insufficiently sound transmissive.

The present invention is oriented toward a solution of these and other problems.

SUMMARY OF INVENTION

An immersion-resistant housing adapted to receive a vibratable diaphragm spanning the interior of the housing to divide the housing into first and second chambers includes a first port communicating between the first chamber and the exterior environment. The first port is configured as a tubulation having an interior volume generally not less than the volume of the first chamber. The tubulation has sufficiently small diameter that water entering therein moves essentially as a piston without breakup. By configuring the tubulation to have a volume at least equal to that of the first chamber, a hydrostatic head of about 32 feet of water is necessary before water can be forced into the first chamber. In the preferred embodiment the diaphragm completely seals the housing against direct communication between the two chambers.

To allow for pressure equalization across the diaphragm under conditions of rapidly varying atmospheric pressure, a second port communicates between the second chamber and the external environment, and selective sealing means are provided for permitting passage of air through the second port while preventing the passage of water therethrough at pressures up to at least three and preferably ten meters of hydrostatic head. In the preferred form of the invention, this is accomplished by covering the second port with a hydrophobic membrane rendered porous by means of sub-micron diameter capillaries running therethrough. Air passes readily through the membrane, but considerable water pressure is necessary before water can enter. Additional strength is imparted to the structure by air-permeable anti-flexure screens disposed in confronting abutting relationship to opposite faces of the membrane.

The housing is equally well adapted to the protection of earphones (receivers) having a motor in the second chamber coupled to the diaphragm to cause sound to exit through the tubulation, or to microphones of, for example, the electrodynamic type having a generator similarly disposed and coupled. For the earphone embodiment an ear plug is provided configured to nestingly retain the housing in a passage in the plug with the tubulation oriented for insertion into the ear canal. The passage is configured to allow access of ambient air to the sealing means.

Other features and advantages of the invention will be evident from the specification to follow, the claims and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cutaway side view of the inventive housing with a diaphragm and an earphone motor disposed therein.

FIG. 2 is a bottom view of the housing shown in FIG. 1.

FIG. 3 is a partially exploded view of the housing and an associated earplug.

FIG. 4 is a detail view of a portion of the assembly shown in exploded form in FIG. 3.

DESCRIPTION OF THE INVENTION

FIGS. 1 and 2 show an immersion-resistant earphone transducer assembly 10 specifically configured for use with a an earphone. The assembly 10 comprises a housing 12 having a partition wall 14 upon which is sealingly secured a flexible diaphragm 16. The diaphragm 16 divides the interior of the housing 12 into two independent chambers, namely an upper sound chamber 18 and a lower motor chamber 20. The lower motor chamber 20 contains an audio-frequency motor, to be discussed subsequently, which drives the diaphragm 16.

As is well known, sound produced by vibration of the diaphragm 16 exits the housing 12 via passages and passes along the interior of a tubulation 23. The interior volume of the tubulation 23 is preferably chosen to be approximately equal to the total interior volume of the sound chamber 18. Since the sound chamber 18 is completely sealed from the motor chamber 20, water entering the tubulation will not enter the sound chamber 18 until an immersion depth of approximately 32 feet is achieved.

To accommodate rapid change in ambient atmospheric pressure, such as during rapid climb or descent of the helicopter, a passage 24 in the motor chamber wall communicates with a selective seal system 25 which passes air freely, but which prevents entry of water when immersed.

In more detail, a generally U-shaped armature 26 disposed within the motor chamber 20 has one end fixedly secured to a permanent magnet structure 27. The free end 28 of the armature 26 passes through a solenoid drive coil 29 and between confronting pole pieces 30, 32 of the permanent magnet structure 27. The solenoid drive coil 29 is excited by electrical signals applied to external terminals 34, 36. The resulting magnetization of the armature 26 causes the free end 28 of the armature 26 to oscillate, this motion being coupled to the diaphragm 16 by means of a coupling rod 38 moving within a passage 39 in the partition wall 14. The sound chamber 18 is provided with a sound outlet passage 21 at one end. The sound produced by vibrations of the diaphragm 16 are thus transmitted outside of the housing 12 through the passage 21. An outlet chamber 42 is provided mounted on one end of the housing 12 and is sealed in communication with the passage 21. The outlet chamber 42 has an exterior passage 22. The outer end 50 of the outlet chamber 42 is generally cylindrical, and the tubulation 23 is press-fitted in place, to be secured in place by a fillet 52 of an appropriate bonding agent, such as self-vulcanizing silicone. In the preferred embodiment, the tubulation 23 is made of polytetrafluoroethylene, principally because of its ease of cleaning. Sound originating in the sound chamber 18 will thus ultimately emerge from the outer end 53 of the tubulation 23.

In the particular transducer assembly 10 shown, the housing 12 exclusive of the outlet chamber 42 is approximately 0.350" (8.9 millimeters) in length. The volume of the sound chamber 18 is approximately 18 cubic millimeters. The tubulation 23 has an interior diameter of 1.5 millimeters and a length of approximately 10.2 millimeters, and thus has a volume of approximately 18 cubic millimeters. It will therefore be appreciated that as the transducer assembly 10 is immersed in water to increasing depth, two things will happen.

First, because of the small interior diameter of the tubulation 23, water entering the tubulation will, because of surface tension affects, move essentially as a continuous piston towards the housing. Since the volume of the tubulation 23 and the interior volume of the sound chamber 18 are equal it follows that, irrespective of what the atmospheric pressure was prior to immersion, the plug of water entering the passage 54 will not reach the passage 21 leading to the sound chamber 18 until the total pressure of water (atmospheric pressure plus hydrostatic head) equals two atmospheres. Thus there must be one atmosphere of hydrostatic head for this to occur, corresponding to an immersion depth of approximately 32 feet (9.7 meters). Upon return to the surface, the water in the passage 54 will immediately be expelled.

In prior art transducer assemblies, the motor chamber 20 communicates with the sound chamber 18 by means of a small aperture in the diaphragm 16. This venting is done so that variations in ambient pressure communicated to the sound chamber from the external environment as well as changes in the temperature within the motor chamber 20 do not induce distortion-producing offsetting of the diaphragm 16. The purpose of such a passage is provide a slow leakage between the two chambers 18, 20 so as to maintain equal static pressure on opposite sides of the diaphragm 16. The transducer assembly 10 of the present invention must be able to accommodate extremely rapid changes in atmospheric pressure. A small diaphragm passage will not accommodate such rapid variations in air pressure, and if a diaphragm passage were configured with sufficient area to accommodate such rapid pressure variations, then the motor chamber 20 would effectively be in communication with the sound chamber 18, thus raising the effective interior volume by more than an order of magnitude. The tubulation 23 in such a case would have to be made so long as to be useless.

Accordingly, in the preferred form of the invention, the diaphragm 16 has no aperture passing therethrough and ambient pressure equalization in the motor chamber 20 is achieved by means of the passage 24 in one face of the motor chamber 20 covered by a seal system 25 which allows the free flow of air into and out of the motor chamber, but which is impervious to water.

Considering the seal system 25 in more detail and with particular reference to FIGS. 3 and 4, the passage 24 communicating with the motor chamber 20 has a rectangular configuration. A circular seal cap 58 has a corresponding rectangular passage 60 passing through the central portion thereof. A shallow well 62 is provided in the seal cap and in this well are emplaced sequentially a stiffener screen 64, a permeable membrane 66, and another stiffener screen 68. The periphery of the permeable membrane 66 is secured to the walls of the well 62 by a fillet 70 of a suitable water-proof cement. The entire assembly is then emplaced over the passage 24 in the housing 12, and the seal cap 58 is hermetically sealed thereto, as for example, by laser seam welding.

The particular material used for the permeable membrane is porous polytetrafluoroethylene film marketed under the name Tetratex by the Tetratec Corporation of Feasterville, Pa., U.S.A. This membrane has a thickness of 0.0015" (0.038 millimeters) and an effective pore size of 0.22 microns. Since the material from which it is made is hydrophobic, water is effectively barred from entry through the pores. On the other hand, the air flow rate is greater than 5 cubic centimeters per square centimeter of membrane at a pressure differential of 9 millimeters of mercury. Seal system 25 provides adequate venting during rapid variation of atmospheric pressure, and also serves to prevent entry of water into motor chamber 20 attendant to 10 meter immersion.

FIG. 3 also shows an ear plug 74 to be used in conjunction with the transducer assembly 10 when it is configured as an earphone (receiver). The ear plug 74 is preferably of soft elastomeric material such as silicone rubber, and is generally cylindrical, having a generally planar outer face 76 and an inner face 78 adapted to conform to the contours of the ear in the vicinity of the ear canal. A first passage 80 is configured to insertingly accept the lateral dimensions of the housing 12. The ceiling 82 of the passage 80 has an arcuate shape to allow pneumatic communication to the passage 60 of the seal cap 58. A second passage 84 communicates between the inner end 78 of the ear plug 74 and the inner end of the passage 80, and is configured to insertingly accept the tubulation 23 of the transducer assembly 10 to extend into the ear canal. An optional sealing-type slide-on ear plug (not shown) conformed to seal into the ear canal may optionally be provided.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the broader aspects of the invention. Thus, the housing is equally well adapted to the protection of earphones (receivers) having a motor in the second chamber coupled to the diaphragm to cause sound to exit through the tubulation, or to microphones of, for example, the electrodynamic type having a generator similarly disposed and coupled.

Also, it is intended that broad claims not specifying details of a particular embodiment disclosed herein as the best mode contemplated for carrying out the invention should not be limited to such details. Furthermore, while, generally, specific claimed details of the invention constitute important specific aspects of the invention in appropriate instances even the specific claims involved should be construed in light of the doctrine of equivalents.

We claim:

1. In an immersion-resistant housing adapted to receive a vibratable diaphragm spanning the interior of said housing and dividing said housing into first and second chambers of given volumes sealed from interior pneumatic communication with each other, and including a first port communicating between said first chamber and the exterior environment, the improvement comprising:

said first port configured as an extended tubulation open to fluid and sonic flow, said tubulation having a cross-sectional dimension sufficiently small that water forced into said tubulation from said exterior environment by immersion will travel as a homogeneous plug without breakup;

a second port communicating between said second chamber and the external environment; and

selective sealing means for permitting passage of air through said second port while preventing the passage of water therethrough.

2. The housing of claim 1 wherein said sealing means includes means for preventing the passage of water therethrough at pressures up to at least three meters of hydrostatic head.

3. The housing of claim 1 wherein said sealing means includes a planar membrane of hydrophobic material having a plurality of capillary air passages extending therethrough.

4. The housing of claim 3 wherein said sealing means includes first and second planar screens disposed in confronting abutting relationship to opposite faces of said hydrophobic membrane.

5. The housing of claim 4 including an earplug having first and second generally opposing outer surfaces and configured for emplacement into the exterior portion of a user's ear, said earplug including a first passage communicating with said first surface and configured to insertingly accept said housing and a second passage communicating between said second surface and said first passage and configured to insertingly accept said tubulation to project beyond said second surface and into a user's ear canal, said first passage being configured to provide fluid communication between said sealing means and said first surface.

6. An immersion-resistant audio frequency transducer comprising:

a housing;

a vibratable diaphragm spanning the interior of said housing and dividing said housing into a first chamber and a second chamber of given volumes sealed from interior pneumatic communication with each other;

one of an audio frequency motor and an audio frequency generator disposed within said second chamber and coupled to said diaphragm;

a first port communicating between said first chamber and the exterior environment, said outlet port being configured as an elongated tubulation open to fluid and sonic flow, said tubulation having an inner cross-sectional dimension sufficiently small that water forced into said tubulation from said exterior environment by immersion will travel as a homogeneous plug without breakup, said tubulation having an interior volume generally not less than one half the volume of said first chamber;

a second port communicating between said second chamber and the external environment; and

selective sealing means for permitting passage of air through said second port while preventing the passage of water therethrough at pressures up to at least three meters of hydrostatic head.

7. The transducer of claim 6 wherein said sealing means includes a planar membrane of hydrophobic material having a plurality of capillary air passages extending therethrough.

8. The transducer of claim 7 wherein said sealing means includes first and second planar screens disposed in confronting abutting relationship to opposite faces of said hydrophobic membrane.

9. The transducer of claim 8 including an earplug having first and second generally opposing outer surfaces and configured for emplacement into the exterior portion of a user's ear, said earplug including a first passage communicating with said first surface and configured to insertingly accept said housing and a second passage communicating between said second surface and said first passage and configured to insertingly accept said outlet port tubulation to project beyond said second surface and into a user's ear canal, said first passage being configured to provide fluid communication between said seal and first surface, said transducer being a motor for exciting vibrations in said diaphragm responsively to electrical signals applied to said motor.

10. An immersion-resistant audio frequency transducer comprising:

a housing;

a vibratable diaphragm spanning the interior of said housing and dividing said housing into a first chamber and a second chamber of given volumes sealed from interior pneumatic communication with each other;

one of an audio frequency motor and an audio frequency generator disposed within said second chamber and coupled to said diaphragm;

a first port communicating between said first chamber and the exterior environment, said first port being configured as an elongated tubulation open to fluid and sonic flow, said tubulation having an inner cross-sectional dimension sufficiently small that water forced into said tubulation from said exterior environment by immersion will travel as a homogeneous plug without breakup, said tubulation having an interior volume generally not less than one half the volume of said first chamber;

a second port communicating between said second chamber and the external environment;

a selective seal disposed sealingly across said second port, said seal including a planar membrane of hydrophobic material having a plurality of capillary air passages extending therethrough so as to be air-permeable but impermeable to water; and

first and second planar screens disposed in confronting abutting relationship to opposite faces of said hydrophobic membrane.

11. The transducer of claim 10 wherein said selective seal includes a means for preventing the passage of water therethrough at pressures up to at least five meters of hydrostatic head.

12. The transducer of claim 10 including an earplug having first and second generally opposing outer surfaces and configured for emplacement into the exterior portion of a user's ear, said earplug including a first passage communicating with said first surface and configured to insertingly accept said housing and a second passage communicating between said second surface and said first passage and configured to insertingly accept said sound port tubulation to project beyond said second surface and into a user's ear canal, said first passage being configured to provide fluid communication between said seal and first surface, said transducer being a motor for exciting vibrations in said diaphragm responsively to electrical signals applied to said motor.

13. The housing of claim 1 wherein said tubulation has an interior volume generally not less than one half the volume of said first chamber.

14. The housing of claim 13 wherein said tubulation has an interior volume approximately equal to that of said first chamber.

15. The housing of claim 2 wherein said sealing means includes a means for preventing the passage of water therethrough at pressures up to at least ten meters of hydrostatic head.

16. The transducer of claim 6 wherein said tubulation has an interior volume approximately equal to that of said first chamber.

17. The transducer of claim 6 wherein said sealing means includes a means for preventing the passage of water therethrough at pressures up to at least ten meters of hydrostatic head.

18. The transducer of claim 10 wherein said tubulation has an interior volume approximately equal to that of said first chamber.

19. The transducer of claim 10 wherein said selective seal includes a means for preventing the passage of water therethrough at pressures up to at least ten meters of hydrostatic head.

20. The transducer of claim 6 wherein said one of an audio frequency motor and an audio frequency generator is an audio frequency generator.

21. The transducer of claim 10 wherein said one of an audio frequency motor and an audio frequency generator is an audio frequency generator.

22. The housing of claim 13 wherein said sealing means includes a means for preventing the passage of water therethrough at pressures up to at least three meters of hydrostatic head.

23. The housing of claim 22 wherein said sealing means includes a means for preventing the passage of water therethrough at pressures up to at least ten meters of hydrostatic head.

24. The housing of claim 13 wherein said sealing means includes a planar membrane of hydrophobic material having a plurality of capillary air passages extending therethrough.

25. The housing of claim 24 wherein said sealing means includes first and second planar screens disposed in confronting abutting relationship to opposite faces of said hydrophobic membrane.

26. The housing of claim 25 including an earplug having first and second generally opposing outer surfaces and configured for emplacement into the exterior portion of a user's ear, said earplug including a first passage communicating with said first surface and configured to insertingly accept said housing and a second passage communicating between said second surface and said first passage and configured to insertingly accept said tubulation to project beyond said second surface and into a user's ear canal, said first passage being configured to provide fluid communication between said sealing means and said first surface.

27. The housing of claim 14 wherein said sealing means includes a means for preventing the passage of water therethrough at pressures up to at least three meters of hydrostatic head.

28. The housing of claim 27 wherein said sealing means includes a means for preventing the passage of water therethrough at pressures up to at least ten meters of hydrostatic head.

29. The housing of claim 14 wherein said sealing means includes a planar membrane of hydrophobic material having a plurality of capillary air passages extending therethrough.

30. The housing of claim 29 wherein said sealing means includes first and second planar screens disposed in confronting abutting relationship to opposite faces of said hydrophobic membrane.

31. The housing of claim 30 including an earplug having first and second generally opposing outer surfaces and configured for emplacement into the exterior portion of a user's ear, said earplug including a first passage communicating with said first surface and configured to insertingly accept said housing and a second passage communicating between said second surface and said first passage and configured to insertingly accept said tubulation to project beyond said second surface and into a user's ear canal, said first passage being configured to provide fluid communication between said sealing means and said first surface.

* * * * *

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United States Patent [19]

Press

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[45] Date of Patent: Aug. 22, 2000

[54] **WATER RESISTANT SLIDE FASTENER AND PROCESS FOR PREPARING SAME**

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[21] Appl. No.: **09/160,651**

[22] Filed: **Sep. 25, 1998**

[51] **Int. Cl.**[7] **A44B 19/32**

[52] **U.S. Cl.** **24/389**; 24/384; 24/398; 24/408

[58] **Field of Search** 24/389, 394, 403, 24/384, 398, 397, 408

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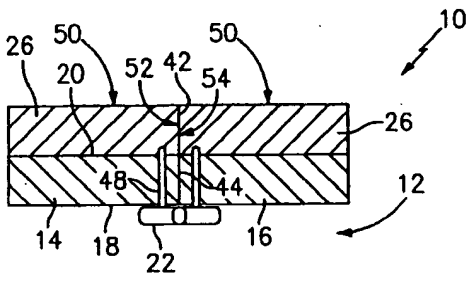
Primary Examiner—Victor N. Sakran

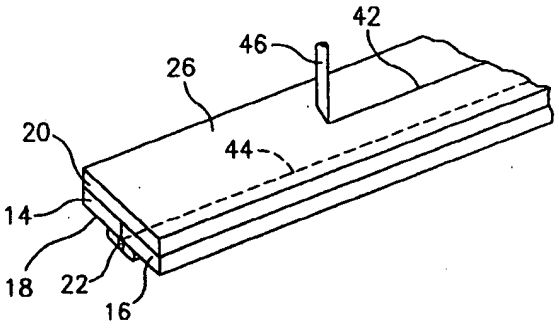
Attorney, Agent, or Firm—Bachman & LaPointe, P.C.

[57] **ABSTRACT**

A water resistant slide fastener, including a pair of stringer tapes each having first and second opposed surfaces and each having a series of gripper elements positioned along edges of said first surface; and a water resistant layer on said second surfaces, wherein said water resistant layer has an adhesion to said stringer tapes of at least about 6 lb/in.

24 Claims, 5 Drawing Sheets





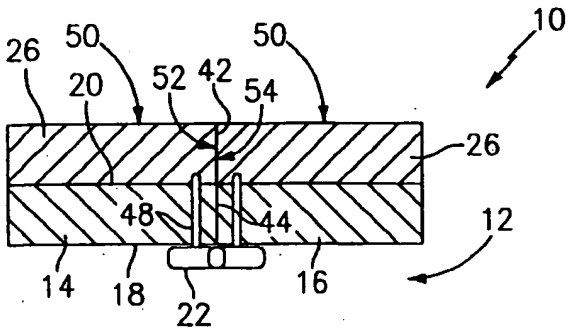


FIG. 1

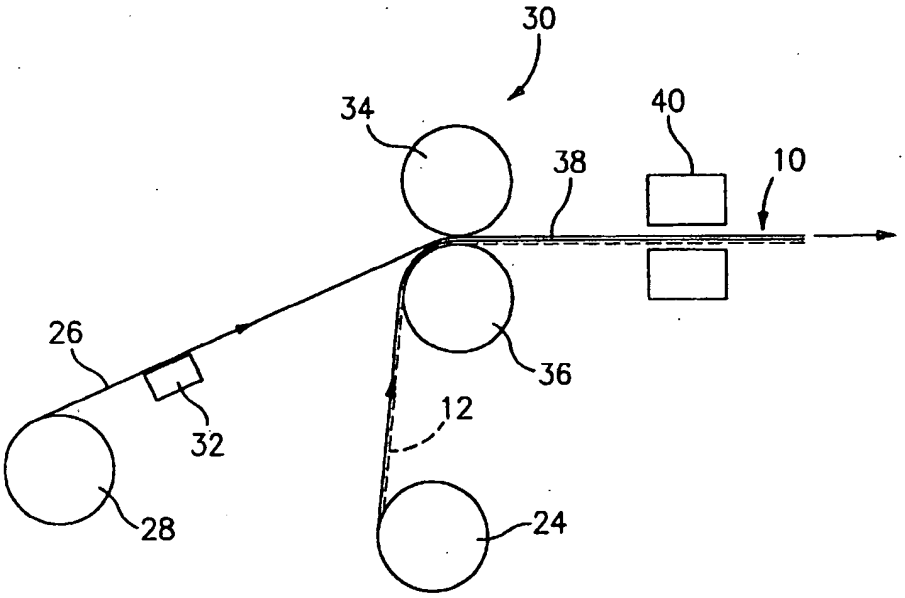


FIG. 2

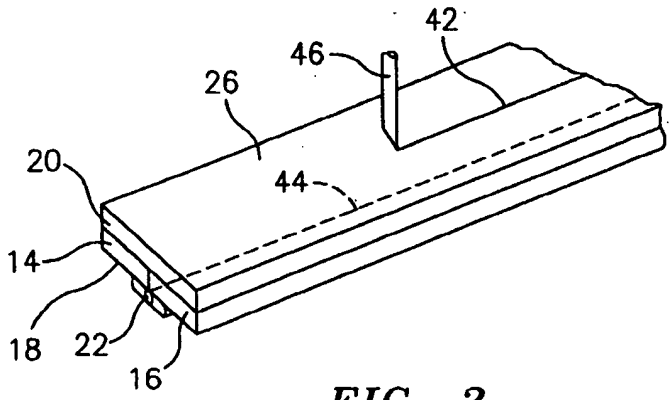


FIG. 3

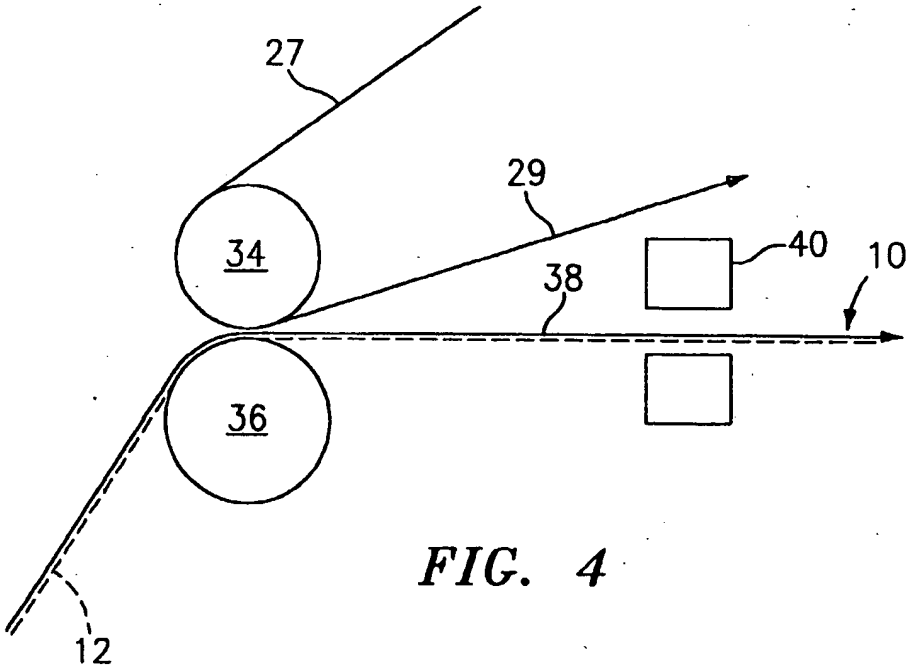


FIG. 4

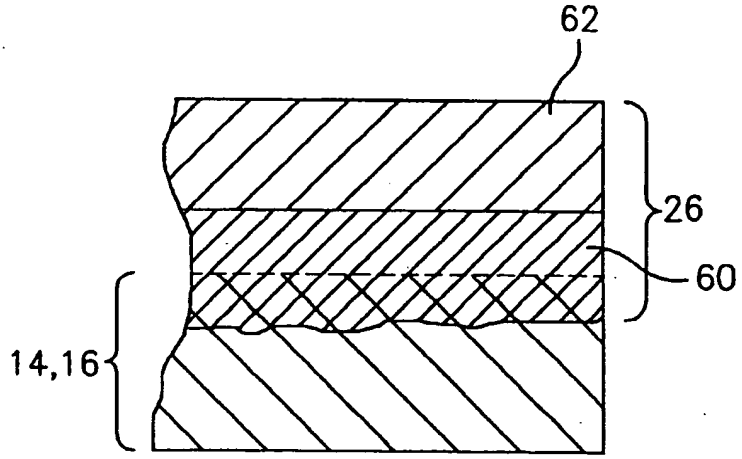


FIG. 5

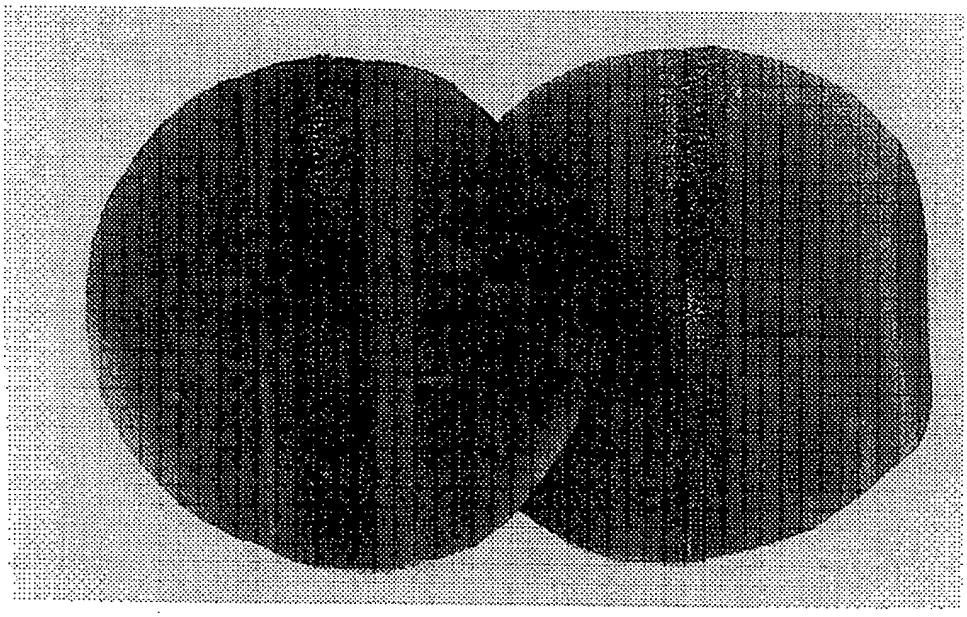


FIG. 6

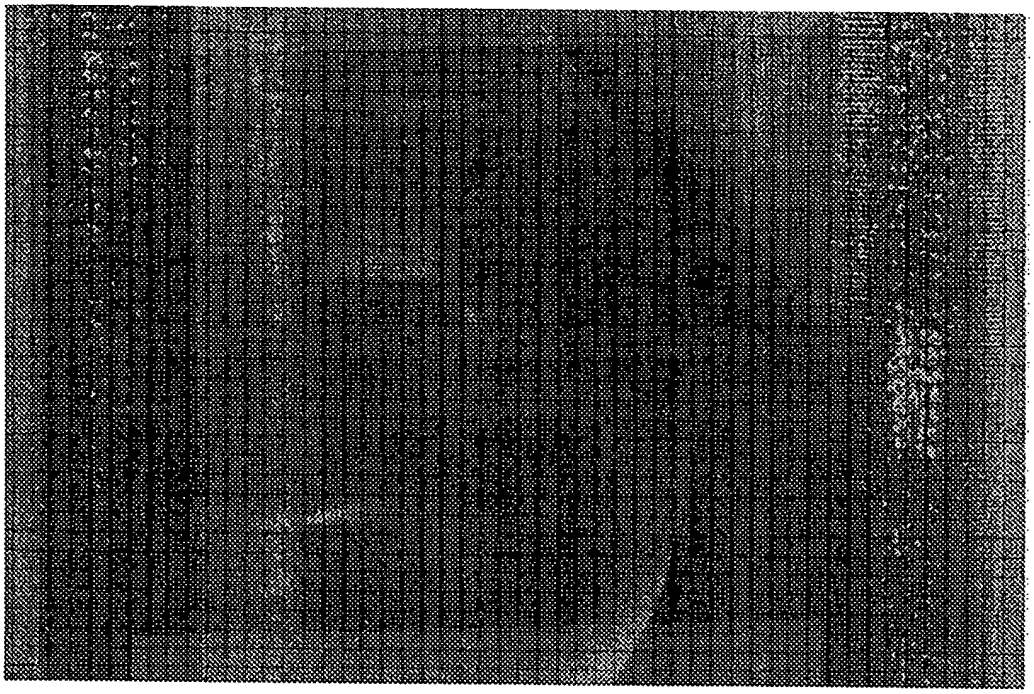


FIG. 7

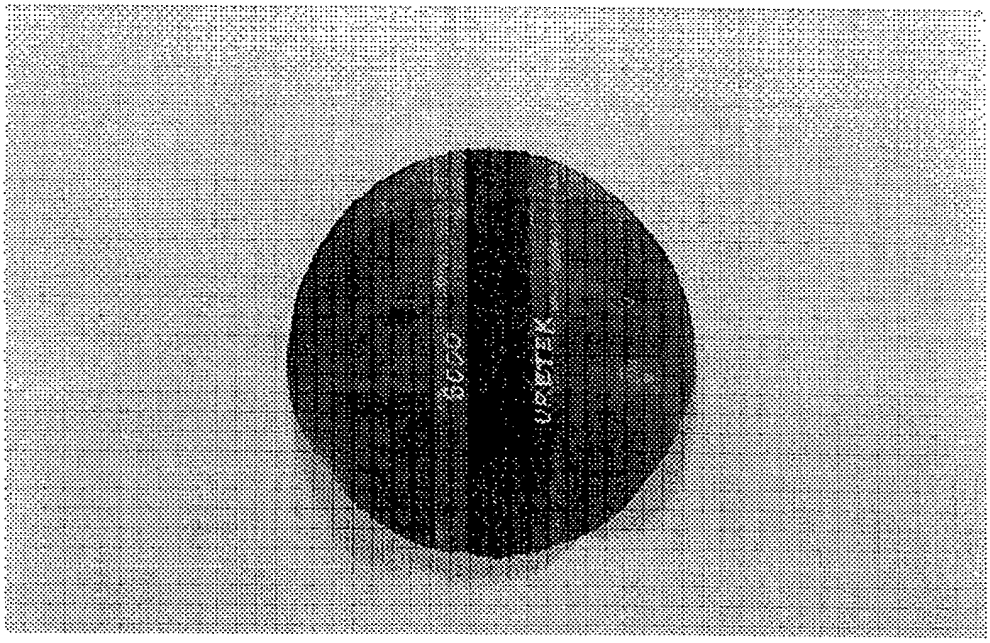


FIG. 8

WATER RESISTANT SLIDE FASTENER AND PROCESS FOR PREPARING SAME

BACKGROUND OF THE INVENTION

The invention relates to a water resistant slide fastener and to a process for preparing same.

Numerous water resistant articles such as high-performing outerwear, jackets, coats, pants, gloves, back packs, daypacks, tents and the like are used in a wide variety of environments and applications. These articles are typically made of water proof or water-resistant material as desired, but also typically require closures or slide fasteners such as zippers and the like which can be a source of leakage.

A number of proposals have been made to address this problem. Examples of such efforts include U.S. Pat. Nos. 4,888,859, 5,386,616 and 5,444,898.

U.S. Pat. No. 4,888,859 to Morita involves the positioning of a filling core in spaces or gaps defined by the gripping elements of a slide fastener. The core is said to swell when contacted by water so as to prevent entry of liquid into the garment. This type of slide fastener has also been used with a hydrophobic core. The back surface of the '859 slide fastener is solution coated with a layer of polyurethane resin.

A problem with the '859 fastener is that the fastener must be positioned with the polyurethane coating on the inside surface so as to protect the coating from abrasion and the like. Unfortunately this exposes the fastener structure or coils to outside wear and abrasion, can detract from the appearance of the slide fastener in the garment, and does not give the appearance of a water resistant closure to consumers.

Further, with the coating positioned inside a garment or article, it is undesirable to tape to the coating material as the material has insufficient adhesion to the underlying stringer tapes, and this adhesion drops after laundering.

Positioning of this fastener with the coating facing outward, however, also leads to problems as the coating does not stand up to abrasion, which leads to loss of performance and leakage.

U.S. Pat. No. 5,386,616 to Norvell describes a water resistant closure wherein a water resistant coating is applied to the stringer tapes of a slide fastener, and water repellant treatment is relied upon for the actual gripper structure. Unfortunately, such treatments have been found to break down when subjected to wear, tear and soiling. Therefore, the slide fastener of Norvell '616 is not suitable as the primary water resistant, and additional flaps or other structures of the garments are required. Furthermore, consumers are uncomfortable with water protection that cannot be seen, and there is therefore a low perceived value to invisible barriers such as fluorocarbon treatment and the like.

An alternative approach is disclosed in U.S. Pat. No. 5,444,898 which discloses a slide fastener wherein an internal flap is arranged to pass behind the actual grippers of the slide fastener so as to resist water seepage therethrough, and an additional flap is positioned to pass in front of the coils of the fastener structure. Although this structure serves to enhance the water resistance of the fastener, the extra flaps make for a structure which can be cumbersome and bulky, and is therefore undesirable for use with articles where flexibility is critical such as for example, "pit-zips" of high performing outerwear.

The need remains for a simple and durable slide fastener which is resistant to passage of water while maintaining a pleasing appearance without the need for additional flaps or other structure and further while resisting breakdown due to outside abrasion.

It is therefore the primary object of the present invention to provide a water resistant slide fastener which provides excellent resistance to passage of water.

It is a further object of the present invention to provide such a water resistant slide fastener which is resistant to damage due to abrasion and the like.

It is still another object of the present invention to provide a water resistant slide fastener having a water resistant layer which has excellent resistance to abrasion and loss of adhesion.

It is still another object of the present invention to provide a water resistant slide fastener which can be easily incorporated into water resistant articles or garments through a variety of methods including direct heat-sealing without securing.

Other objects and advantages of the present invention will appear hereinbelow.

SUMMARY OF THE INVENTION

In accordance with the present invention, the foregoing objects and advantages have been readily attained.

According to the invention, a water resistant slide fastener is provided which comprises a pair of stringer tapes each having first and second opposed surfaces and each having a series of gripper elements positioned along edges of said first surface; and a water resistant layer on said second surface, wherein said water resistant layer has an adhesion to said stringer tapes of at least about 6lb/in.

In further accordance with the invention, the water resistant layer more preferably has an adhesion to the stringer tapes of at least 25lb/in.

Advantageously, the polyurethane layer is capable of withstanding significant abrasion, at least about 200 Stoll abrasion cycles, without perforation, thereby providing a slide fastener which can be positioned in garments with the polyurethane layer oriented facing outwardly.

BRIEF DESCRIPTION OF THE DRAWINGS

A detailed description of preferred embodiments of the invention follows, with reference to the attached drawings, wherein:

FIG. 1 is a sectional view of a slide fastener according to the invention;

FIG. 2 is a side schematic view of a process for preparing a slide fastener in accordance with the present invention;

FIG. 3 is a perspective view of a section of slide fastener in accordance with the present invention including illustration of a cutting step in accordance with a preferred embodiment;

FIG. 4 schematically illustrates an alternative process for applying solid water resistant film in accordance with the present invention;

FIG. 5 illustrates an enlarged portion of a slide fastener in accordance with a preferred embodiment of the present invention;

FIG. 6 is a side-by-side comparison of a slide fastener according to the present invention as compared to a slide fastener according to the prior art, and showing the polyurethane coating or layer after being subjected to a Stoll abrasion test of 1100 cycles;

FIG. 7 is an enlargement of the illustration of FIG. 6 showing more detail of the abraded portions; and

FIG. 8 shows a sample according to the present invention which has been subjected to 8000 abrasion cycles and remains in excellent condition.

DETAILED DESCRIPTION

The invention relates to a water resistant slide fastener, particularly to a slide fastener which is effective in resisting passage of water and the like and which can easily be positioned in closures of water resistant articles without the need for sealing flaps or water absorptive wicks or cores, and which has a water resistant polyurethane layer which is extremely resistant to abrasion and the like, and which has a very durable bond to the fabric of the stringer tapes. This allows the slide fastener to be positioned with the water resistant layer facing outward in a water resistant article or garment.

FIG. 1 shows a sectional view of a slide fastener **10** in accordance with the present invention. Slide fastener **10** includes a slide fastener structure **12**, and stringer tapes **14, 16** each having opposed surfaces **18, 20**. A gripper or coil structure **22** of slide fastener structure **12** is attached to edges of opposed surfaces **18**, for example using stitches **48**. Slide fastener **10** in accordance with the present invention has laminated to surfaces **20** of stringer tapes **14, 16**, a sheet, film or layer **26** of water resistant material, preferably a polyurethane film.

Polyurethane film is preferably laminated, transfer coated, or transfer laminated to stringer tapes **14, 16** as a solid sheet and provided with cut line **42** so as to provide a parting line for film **26** which is substantially coincident with parting line **44** of stringer tapes **14, 16**. Film **26** and cut line **42** are preferably provided so as to provide sections **50** of film **26** each having end surfaces **52, 54** which are reasonably square in nature so as to provide contact or near contact between end surfaces **52, 54** which serve advantageously to provide excellent resistance to permeation of water.

This structure of slide fastener **10** is particularly advantageous in that the bonding process provides film **26** laminated to stringer tapes **14, 16** with excellent adhesion strength and resistance to abrasion while maintaining a flexible, soft, and supple closure. This adhesion strength and abrasion resistance advantageously allows for slide fastener **10** to be positioned with film **26** oriented facing outward on an article or garment, so as to shield gripper elements **22**, threads **48** and stringer tapes **14, 16** from exposure to outside wear and tear. This is advantageous from both a leakage and a wear standpoint, and cannot practically be done using conventionally applied coatings or films which are rapidly rendered ineffective by normal wear and tear or are too thick and result in a fastener which is not sufficiently flexible or easily operable due to high coefficient of friction. Further, this orientation of slide fastener **10** in accordance with the present invention allows for complete elimination of additional closure flaps and the like which are cumbersome to use and can reduce flexibility along slide fastener **10** as well as flexibility of the garment overall. Slide fastener **10** according to the present invention including laminated layer **26** of polyurethane is advantageous over structures such as that disclosed in the aforesaid U.S. Pat. No. 4,888,859, wherein polyurethane is believed to be solution-coated to the stringer tape, in that the laminated layer **26** in accordance with the present invention has a markedly greater adhesion strength to the stringer tapes **14, 16** and further has excellent abrasion resistance as compared to such solution coating.

Lamination of a solid sheet of water resistant material to stringer tapes **14, 16** also advantageously provides for uniform coverage of stitches **48**, which are frequently insufficiently covered using a solution-coating process. Furthermore, the location of such stitches is frequently the area where abrasion first penetrates the water resistant film, thereby exposing a critical element of the entire device. Damage to stitching **48** which can result from exposure through an abraded water resistant layer can result in separation of gripper elements **22** from stringer tapes **14, 16**, thereby completely destroying the effectiveness of slide fastener **10**.

As will be demonstrated below, laminated coating **26** advantageously exhibits an adhesion strength as measured by Federal Test Standard 191A, Method No. 5970, of at least about 6 pounds per inch of width of heat seal peel adhesion, and more preferably at least about 10 pounds per inch of width, most preferable at least about 25 pounds per inch of width. Such adhesion is a marked improvement over the solution coated structures of the prior art, which delaminate at an adhesion strength less than 6 pounds per inch of width.

Furthermore, the laminated layer **26** in accordance with the present invention has excellent resistance to abrasion. As will be demonstrated below, laminated layer **26** according to the invention readily resists over 1000 cycles of Stoll abrasion testing (Federal Test Standard 191A, Method No. 5302) without any significant loss of structural integrity, while prior art coatings show noticeable wear and perforation after only 200 cycles. Laminated layer **26** is bonded to the fabric of stringer tapes **14, 16** in such a way that repeated laundering does not significantly impact upon the adhesion strength or abrasion resistance, thereby providing a slide fastener wherein the polyurethane surface can be positioned outwardly, and subjected to normal wear and tear, without presenting problems such as early structural failure of the water resistant layer, and further without the layer being damaged or impacted so as to present an undesirable appearance.

As used herein, the abrasion cycles referred to are cycles of abrasion using a Stoll abrasion tester operating with a No. 8 cotton duck unbleached material having a weight of about 18 ounces per square yard and an approximate thread count of about 44x30 threads per inch as an abrader, with the sample being tested while oriented in the machine in the warp direction, and with a one pound weight on the head of the abrader device. Such abrasion testing is further illustrated in the Example below. Suitable abrader can be obtained from Burcott Mills of Chicago, Ill.

Slide fastener structure **10** according to the present invention includes layer **26** laminated to stringer tapes **14, 16** with sufficient adhesion strength that when this structure is subjected to adhesion testing such as method 5970 of Federal Test Method Standard No. 191A, the polyurethane bond to the fabric of the stringer tapes has a higher strength than the integrity or material strength of the actual stringer tapes, and therefore, under this test, failure occurs through the stringer tape material, and not along the bond between the polyurethane and stringer tapes.

Inner surface or non-coated surface **18** of stringer tapes **14, 16** may be treated with water repellant treatments such as fluorocarbon treatments, if desired. This may assist in providing a thoroughly water-resistant article. However, long term water resistance is nevertheless provided primarily by the water resistant layer **26**.

In applications where the slide fastener of the present invention must be flexible, for example when used as a "pit-zip" or positioned elsewhere in a high performing outerwear garment, the slide fastener structure must remain

sufficiently flexible so as not to interfere with the free movement of the wearer of the garment. A suitable slide fastener according to the invention, for a No. 5 zipper, will have a flexibility as measured by Clark Stiffness Testing of less than or equal to about 30 cm, more preferably less than or equal to about 25 cm, as set forth in Federal Test Method Standard 191A, Method 5204.

Referring to FIG. **2**, a process for preparing a slide fastener **10** in accordance with the present invention is schematically illustrated. As shown, a slide fastener structure **12** is provided which typically includes two stringer tapes **14, 16** (see FIG. **3**) each having opposed surfaces **18, 20**, and having a gripper structure **22** such as coils, teeth, knobs and the like which can be engaged and disengaged using a slide member (not shown) so as to join stringer tapes **14, 16** as desired.

In accordance with the present invention, slide fastener structure **12** may suitably be provided having stringer tapes **14, 16** arranged in a substantially parallel configuration, with gripper structure **22** arranged on one opposed surface **18** thereof, or along inner edges of tapes **14, 16**. Slide fastener structure **12** may, for example, be provided from a roll **24** of suitable slide fastener structure as schematically shown in FIG. **2**.

Still referring to FIG. **2**, a sheet or layer of water resistant film, preferably polyurethane film, is provided and bonded or laminated to opposed surfaces **20** of stringer tapes **14, 16** so as to provide the desired water resistant slide fastener structure **10** in accordance with the present invention.

As shown in FIG. **2**, polyurethane film **26** is preferably provided, for example from a roll **28**, and fed toward a laminating station **30** where it is laminated or bonded to slide fastener structure **12**. Before reaching laminating station **30**, one surface of polyurethane film **26** may be treated for example at station **32** so as to provide a polyurethane adhesive or bonding material on the surface of polyurethane film to be contacted with opposed surface **20** of slide fastener structure **12** which can then readily be laminated together at laminating station **30**.

The adhesion of the present invention may, if desired, be provided by applying a bonding agent or hot melt adhesive to the polyurethane film before lamination.

Referring to FIG. **4**, a transfer laminating method which can be used in accordance with the present invention for applying water resistant film to stringer tapes of a slide fastener is illustrated. As shown, nip rollers or laminating rollers **34, 36** are provided as in the embodiment of FIG. **2**, and slide fastener structure **12** is fed to rollers **34, 36** as discussed previously. In this embodiment, water resistant film is provided by feeding a sheet of paper or other suitable material to nip rollers **34, 36** which is carrying the desired layer of polyurethane or other water resistant material. This combination of polyurethane and paper is referred to in FIG. **4** by reference numeral **27**. Structure **27** is fed such that the layer of polyurethane faces slide fastener structure **12** while passing through rollers **34, 36**, and during rolling, the polyurethane is transferred from the paper of structure **27** to slide fastener structure **12** as desired. As shown in FIG. **4**, a sheet of paper **29** without polyurethane exits rollers **34, 36**, as does laminated slide fastener **38** as desired in accordance with the present invention. Laminated or coated structure **38** may subsequently be fed to a cutting station **40** as with the embodiment of FIG. **2**, if desired. Such cutting, however, is preferably carried out in a separate process. FIGS. **2** and **4** show this cutting in-line for the sake of simplicity only. A curing step may also be desired after laminating and could be performed at station **40** or in any other convenient manner.

In this manner, polyurethane film can be directly laminated to the fabric stringer tapes **14, 16**, particularly to opposed surfaces **20** thereof, in a manner which provides a very durable, abrasion-resistant, thin and flexible polyurethane coating on surface **20**. This layer **26** of polyurethane also has an excellent adhesion to surface **20** which resists delamination, even after multiple washings. If desired, additional layers of polyurethane and the like can easily be laminated to the initial polyurethane film coating, so as to provide the water resistant slide fastener **10** of the present invention with additional properties if needed.

Referring back to FIG. **1**, it is preferred in accordance with the present invention that layer or film **26** of water resistant material be provided so as to substantially overlay both the inner edges of stringer tapes **14, 16** as well as gripper coils **22**. This is readily accomplished by laminating a solid sheet or layer of polyurethane or other water resistant material to the desired surface **20** of stringer tapes **14, 16**, and subsequently forming a cut along line **42** where illustrated. After substantial use, a small gap may eventually develop between surfaces **52, 54** of polyurethane material **26**. However, such gap will typically be less than about 0.5 mm, and will not effect the proper operation of polyurethane layer **26** in accordance with the present invention.

Referring now to FIG. **5**, a preferred embodiment of the present invention will be further illustrated and described. As set forth above, it may be desirable to provide film **26** as a multilayer structure. FIG. **5** shows film **26** having an inner layer **60** arranged contacting stringer tapes **14, 16** and an outer layer **62** arranged facing away from stringer tapes **14, 16**. In accordance with the present invention, inner layer **60** may preferably be a low melt material, for example having Shore A hardness of less than or equal to about 80 PTPU, while outer layer **62** is provided as an abrasion resistant layer, and may be provided having a hardness preferably greater than or equal to about 90 PTPU. The combined thickness of layer **26** may be provided preferably between about 1 and about 5 mils, more preferably between about 2 and about 2½ mils. In the multilayer embodiment of the present invention, each layer **60, 62** may suitably be provided having a thickness of about 1.5 mils.

As shown in FIG. **5**, the laminating process of the present invention results in a portion of film **26**, preferably a portion of a low melt layer **60** of film **26**, embedding into the material of stringer tapes **14, 16**. This is shown by the overlap in FIG. **5** of layer **60** with stringer tapes **14, 16**. The permeation of film material into the fibers of stringer tapes **14, 16** provided by such lamination serves to provide the excellent adhesion demonstrated by slide fastener **10** in accordance with the present invention and reduces the coefficient of friction to allow for ease of operation. Incorporating a slip agent into the hard layer is also beneficial in this regard. Furthermore, the provision of a hard or abrasion resistant outer layer **62** of film **26** serves to advantageously enhance the abrasion resistance as demonstrated by slide fastener **10** in accordance with the present invention and reduces the coefficient of friction to allow for ease of operation. Of course, it should be appreciated that additional layers may be incorporated into film **26**, if desired.

The water resistant film in accordance with the present invention may be provided of any acceptable material. Specific examples of acceptable material include polyurethane, polyester, polyolefin, nylon, rubber and other thermoplastic hot melt adhesive films.

The present disclosure is made in terms of polyurethane as the water resistant material, which is the preferred

embodiment. Of course, other materials as described above could be equally suitable. It should also be noted that the polyurethane or other water resistant material could include other additives such as pigments, anti-oxidants, slip agents and the like, depending upon specific details of the application.

Stringer tapes **14, 16** in accordance with the present invention are typically provided from a woven or non-woven fabric, preferably a woven fabric, and may suitably be provided from materials such as polyester yarn, nylon yarn, aramid yarn, and the like.

The water resistant film **26** in accordance with the present invention is preferably polyurethane film, although other urethane and similar water resistant films may be used in accordance with the present invention. The preferred polyurethane film in accordance with the present invention has a total thickness of between about 1 and about 5 mils, most preferably at least about 2 mils. Various types and grades of polyurethane and other thermoplastic films are readily available and should be selected depending upon the desired characteristics of the final slide fastener product.

From laminating station **30**, (FIG. 2) polyurethane coated slide fastener structure **38** may suitably be passed to subsequent treating station **40** wherein the polyurethane film **26** may be cured, and/or cut, preferably along a line **42** (FIG. 3) which is substantially parallel to a parting line **44** of gripper structure **22**. This may be carried out using a simple knife structure **46** (see FIG. 3), or with any other similar structure. Providing cut line **42** after laminating film **26** to stringer tapes **14, 16** serves to provide a reasonably squared edge of flat surface **52** (FIG. 1) of polyurethane film which contacts or closely abuts the other squared edge or surface **54** thereof when water resistant slide fastener **10** is closed in accordance with the present invention. This serves advantageously to provide excellent resistance to passage of water through the gripper structure **22** of water resistant slide fastener **10**.

The present invention provides a water resistant coated slide fastener structure **10** having a water resistant polyurethane layer laminated thereto, with excellent adhesion to the stringer tape fabric, thereby providing a slide fastener structure **10** which can advantageously be positioned, for example in an article of clothing, with polyurethane layer **26** facing outwardly in the garment. This would not normally be possible with conventionally coated slide fastener structures, as such coatings are susceptible to removal by abrasion, laundering and other wear and tear, and therefore must be oriented facing inwardly on articles of clothing, or otherwise covered using flaps or other structures. This is particularly advantageous in that positioning of polyurethane coated surfaces **20** facing outward in a garment (1) increases long term abrasion resistance of the coil structure and stitching, (2) provides a higher perception of water resistance due to the visible structural covering of the coil by the polyurethane film, (3) provides increased water resistance, and (4) can also avoid water wicking through or laterally into the garment through the stringer tapes as is allowed by some prior art structures. Slide fastener **10** of the present invention also completely avoids the frequently cumbersome flaps which are used in accordance with the prior art and which add weight and stiffness. Also, the substantial abutting nature of polyurethane coat or film along cut line **42** parallel to parting line **44** of gripper structure **22**, provides excellent resistance to water flow through gripper structure **22**. Further, such positioning also positions gripper coils **22** and the yarns that stitch them in an inside shielded position.

EXAMPLE

Two samples were prepared for use in this example. Sample 1 was a YKK slide fastener having a solution-coat of polyurethane. Sample 2 was a slide fastener laminated with a 2.5 mil layer of polyurethane in accordance with the present invention. Each sample was radio frequency (RF) sealed to a 6 ounce polyurethane coated nylon using a Sealomatic RF sealing machine set at 45 psi of compressed air and using a 1"x4" bar. The sealing was performed using an 8 second dwell time and a 3 second cooling time. The slide fastener samples were sealed to the nylon material in this manner, with the urethane-coated surface of the slide fastener contacting the polyurethane coated surface of the nylon material. The adhesion between the polyurethane coat and slide fastener fabric material was then tested by subjecting each sample to an adhesion test as specified by Federal Standard 191A, Method 5970. The RF seal was sufficient to bond the polyurethane coated nylon to the urethane coated slide fastener for the purposes of this test without the need for additional adhesive. Samples prepared as described above were also subjected to 5 laundering cycles using household laundry detergent at warm water wash/warm water rinse and warm drying cycles. The laundered samples were then subjected to adhesion testing. The results are set out in Table 1.

TABLE 1

	Adhesion Strength		
	Initial (lb/in)	5 Cycles Laundering (lb/in)	% Drop
Sample 1 (Prior Art)	5	3.6	28
Sample 2	40	38.4	4

The urethane coated side of each sample was also subjected to Stoll abrasion testing in accordance with Federal Test Method Standard No. 191A, Method 5302, to determine the abrasion resistance of the polyurethane coating. Each sample was subjected to abrasion cycles using an inflated diaphragm abrasion tester with a No. 8 cotton duck unbleached material having a weight of 18 ounce per square yard as the abradant.

The results of the abrasion testing are set forth in Table 2 below. FIGS. **6** and **7** show Sample 1 on the right and Sample 2 on the left after 1,100 cycles. FIG. **8** shows Sample 2 after 8,000 cycles.

TABLE 2

	Stoll Abrasion				
	Cycles				
	200	500	1000	5000	8000
Sample 1 (Prior Art)	Noticeable wear, slight perforation	Significant perforation	Test Stopped	—	—
Sample 2	Intact	Intact	Intact	Intact	Slight wear visible

As set forth above (Table 1), the laminated slide fastener structure of the present invention demonstrated an adhesion strength strikingly greater than that of solution coated material. By contrast, the prior art solution coated fastener separated cleanly along the interface between polyurethane and fabric, and had an adhesion strength substantially smaller than that of the slide fastener of the present invention. After laundering, the slide fastener of the present invention (Sample 2) exhibited an adhesion strength of 38.4

lb/in, and lost only 4% of on the initial strength, while the adhesion strength of the prior art solution-coated material (Sample 1) had dropped 28% to 3.6 lb/in.

As demonstrated in Table 2 and in the accompanying FIGS. 6, 7 and 8, the polyurethane laminated structure of the present invention also exhibited excellent resistance to abrasion, and remained intact after being subjected to 800 abrasion cycles, while the conventionally solution coated slide fastener was perforated after only 200 cycles. Such abrasion would undesirably impact upon the visual appearance of the slide fastener, and adversely impact upon the capability of this structure to resist flow of water.

Clearly, the laminated polyurethane structure of the present invention shows far superior adhesion strength and abrasion resistance as compared to the conventional solution-coated material.

It is to be understood that the invention is not limited to the illustrations described and shown herein, which are deemed to be merely illustrative of the best modes of carrying out the invention, and which are susceptible of modification of form, size, arrangement of parts and details of operation. The invention rather is intended to encompass all such modifications which are within its spirit and scope as defined by the claims.

What is claimed is:

1. A water resistant slide fastener, comprising:

a pair of stringer tapes each having first and second opposed surfaces and each having a series of gripper elements positioned along edges of said first surface; and

a water resistant layer on said second surfaces, wherein said water resistant layer has an adhesion to said stringer tapes of at least about 6 lb/in, wherein said stringer tapes are arranged substantially parallel having inner edges substantially adjacent to said series of grippers elements, and wherein said water resistant layer is positioned on said second surfaces and overlying said inner edges and said series of gripper elements.

2. A slide fastener according to claim 1, wherein said water resistant layer has an adhesion to said stringer tapes of at least about 10 lb/in.

3. A slide fastener according to claim 1, wherein said water resistant layer has an adhesion to said stringer tapes of at least about 25 lb/in.

4. A slide fastener according to claim 1, wherein said water resistant layer is capable of withstanding at least about 200 Stoll abrasion cycles without perforation.

5. A slide fastener according to claim 1, wherein said water resistant layer is capable of withstanding at least about 500 Stoll abrasion cycles without perforation.

6. A slide fastener according to claim 1, wherein said water resistant layer is capable of withstanding at least about 1000 Stoll abrasion cycles without perforation.

7. A slide fastener according to claim 1, wherein said water resistant layer has a thickness of at least about 1 mil.

8. A slide fastener according to claim 1, wherein said water resistant layer has a thickness of at least about 2 mils.

9. A slide fastener according to claim 1, wherein said water resistant layer has an adhesion to said stringer tapes which is greater than the integral strength of said stringer tapes, whereby said stringer tapes fail before separation of said water resistant layer from said stringer tapes.

10. A slide fastener according to claim 1, wherein said water resistant layer comprises a polyurethane film.

11. A slide fastener according to claim 10, wherein said polyurethane film comprises a multilayer structure including an inner layer arranged facing said stringer tapes and having a shore A hardness of less than or equal to about 80 PTPU, and having an outer layer having a Shore A hardness greater than or equal to about 90 PTPU.

12. A slide fastener according to claim 11, wherein said inner layer has a portion embedded into said stringer tapes.

13. A slide fastener according to claim 11, wherein said inner layer and said outer layer each have a thickness of about 1.5 mils.

14. A water resistant slide fastener, comprising:

a pair of stringer tapes each having first and second opposed surfaces and each having a series of gripper elements positioned along edges of said first surface; and

a water resistant layer on said second surfaces, wherein said water resistant layer is capable of withstanding at least about 200 stoll abrasion cycles without perforation, wherein said stringer tapes are arranged substantially parallel having inner edges substantially adjacent to said series of gripper elements, and wherein said water resistant layer is positioned on said second surfaces and overlying said inner edges and said series of gripper elements.

15. A slide fastener according to claim 14, wherein said water resistant layer is capable of withstanding at least about 500 Stoll abrasion cycles without perforation.

16. A slide fastener according to claim 14, wherein said water resistant layer is capable of withstanding at least about 1000 Stoll abrasion cycles without perforation.

17. A slide fastener according to claim 14, wherein said water resistant layer comprises a polyurethane film.

18. A slide fastener according to claim 17, wherein said polyurethane film comprises a multilayer structure including an inner layer arranged facing said stringer tapes and having a Shore A hardness of less than or equal to about 80 PTPU, and having an outer layer having a Shore A hardness greater than or equal to about 90 PTPU.

19. A slide fastener according to claim 18, wherein said inner layer has a portion embedded into said stringer tapes.

20. A slide fastener according to claim 18, wherein said inner layer and said outer layer each have a thickness of about 1.5 mils.

21. A water resistant slide fastener, comprising:

a pair of stringer tapes each having first and second opposed surfaces, said stringer tapes being positioned substantially parallel and side-by-side so as to provide said stringer tapes with inner and outer edges;

a series of gripper elements positioned along said inner edges for releasably securing said stringer tapes together; and

a water resistant layer on at least one surface of said first and second surfaces and overlying said inner edges and said series of gripper elements, wherein said water resistant layer comprises a polyurethane film having a multilayer structure including an inner layer arranged facing said stringer tapes and having a first shore A hardness, and an outer layer having a second shore A hardness, wherein said second shore A hardness is greater than said first shore A hardness.

22. A slide fastener according to claim 21, wherein said first shore A hardness is less than or equal to about 80 PTPU and said second shore A hardness is greater than or equal to about 90 PTPU.

23. A water resistant slide fastener, comprising:

a pair of stringer tapes each having first and second opposed surfaces and each having a series of gripper elements positioned along edges of said first surface; and

a water resistant layer on said second surfaces, wherein said slide fastener exhibits a Clark stiffness of less than or equal to about 30 cm, wherein said stringer tapes are arranged substantially parallel having inner edges substantially adjacent to said series of gripper elements, and wherein said water resistant layer is positioned on said second surfaces and overlying said inner edges and said gripper elements.

24. A water resistant slide fastener, comprising:

a pair of stringer tapes each having first and second opposed surfaces and each having a series of gripper elements positioned along edges of said first surfaces; and

a water resistant layer on said second surfaces, wherein said water resistant layer has an adhesion to said stringer tapes of at least about 6 lb/in, wherein said water resistant layer has an adhesion to said stringer tapes which is greater than the integral strength of said stringer tapes, whereby said stringer tapes fail before separation of said water resistant layer from said stringer tapes.

* * * * *

United States Patent [19]

Siebold et al.

[11] **4,420,706**

[45] **Dec. 13, 1983**

[54] **CONNECTOR ASSEMBLY FOR A PIEZOELECTRIC TRANSDUCER**

[75] Inventors: **Donald J. Siebold, Naperville; Michael K. Troy, Westmont; William R. Lenz, Crestwood, all of Ill.**

[73] Assignee: **Molex Incorporated, Lisle, Ill.**

[21] Appl. No.: **335,071**

[22] Filed: **Dec. 28, 1981**

Related U.S. Application Data

[63] Continuation of Ser. No. 138,088, Apr. 7, 1980, abandoned, which is a continuation of Ser. No. 3,477, Jan. 15, 1979, abandoned.

[51] **Int. Cl.**³ **H01L 41/08**

[52] **U.S. Cl.** ..... **310/324**; 179/110 A; 310/322

[58] **Field of Search** ..... 310/321, 322, 324, 348, 310/354-356; 179/110 A; 339/17 R, 17 C, 17 CF

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Primary Examiner—Mark O. Budd

Attorney, Agent, or Firm—Louis A. Hecht

[57] **ABSTRACT**

A connector assembly for electrically connecting a transducer to another circuit member. The transducer is in the form of a thin wafer and has a conductive substrate with a piezoelectric element mounted thereon. The connector assembly generally includes a base means for removably securing the transducer and electrically connecting it to the circuit element.

17 Claims, 7 Drawing Figures

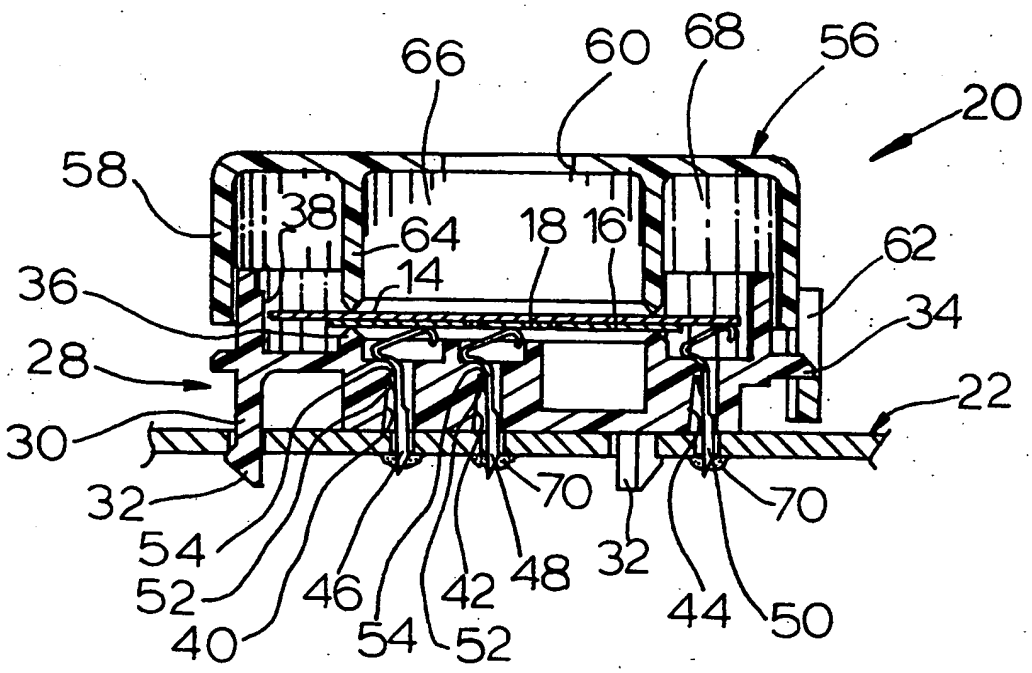
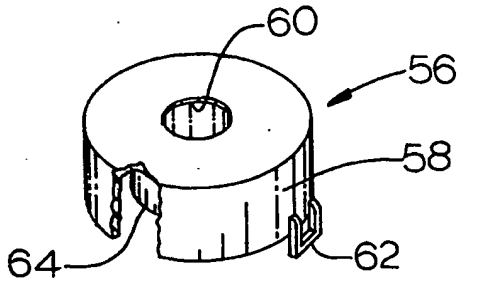


FIG. 1



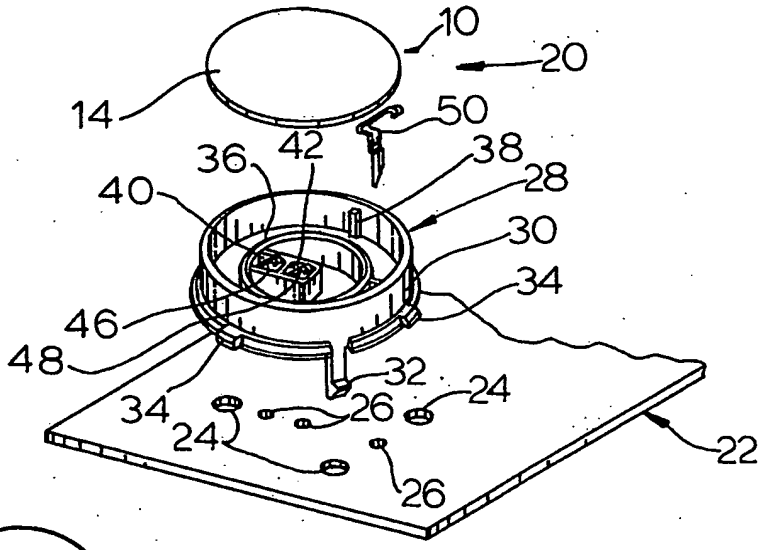


FIG. 2

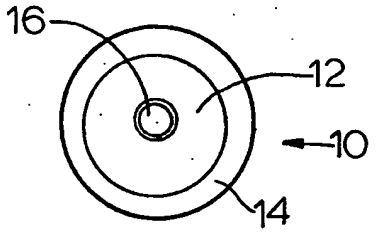


FIG. 3

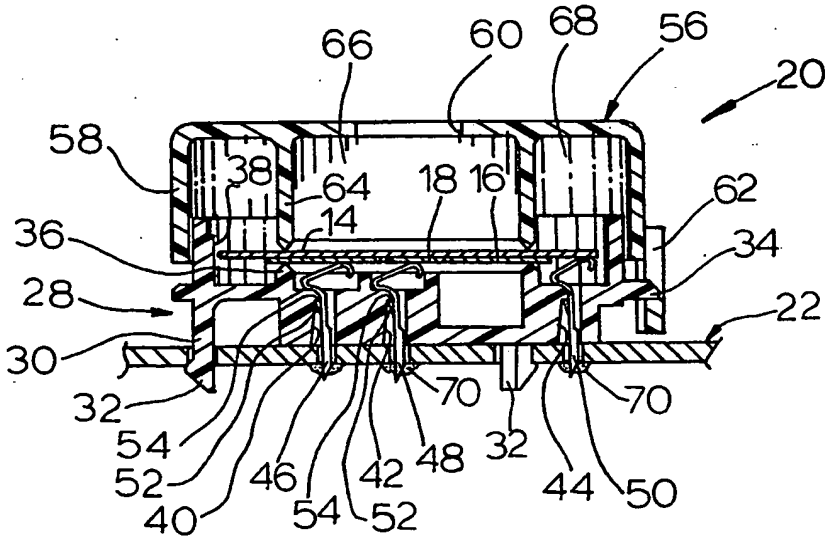


FIG. 4

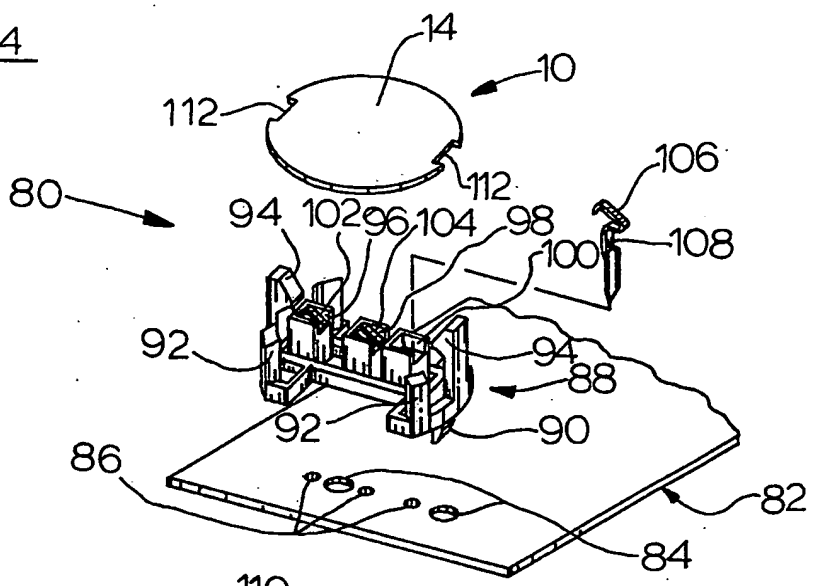


FIG. 5

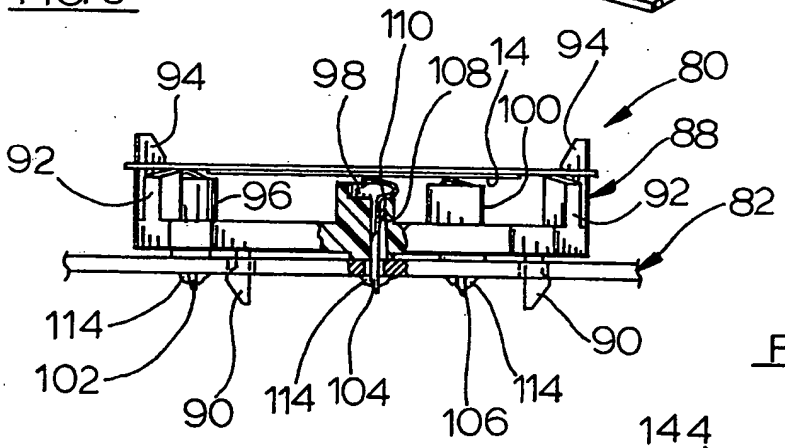


FIG. 6

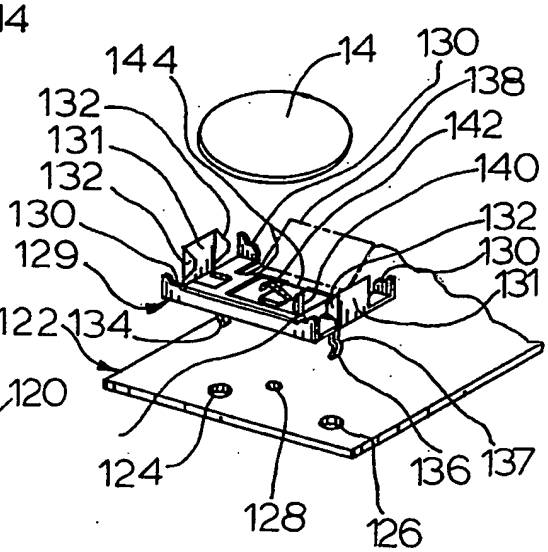
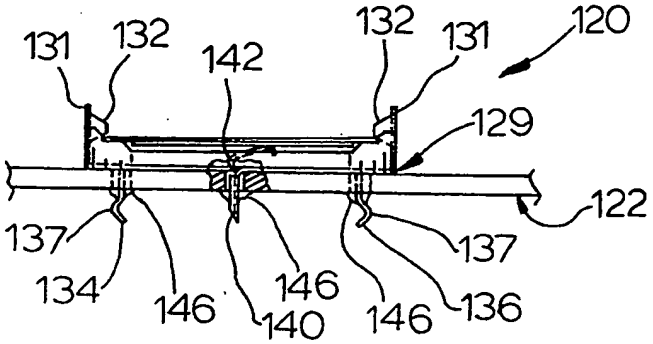


FIG. 7



CONNECTOR ASSEMBLY FOR A PIEZOELECTRIC TRANSDUCER

This application is a continuation of application Ser. No. 138,088, filed Apr. 7, 1980, which is a continuation of Ser. No. 3,477 filed Jan. 15, 1979, both now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to accoustic wave devices such as transducers and more particularly to the electric connection of such transducers to other circuit members.

2. Description of the Prior Art

Transducers, which are generally well known in the art, are made of piezoelectric material. When the piezoelectric material is excited such as by an electrical signal, the transducer will vibrate and, in some applications, will produce a noise in response thereto.

In one kind of application, a transducer in the form of a thin piezoelectric element is mounted on a conductive substrate. By connecting an electrical signal to the element and the other to the conductive substrate, the transducer will be driven (or vibrated) at a given frequency.

In order to get a larger sound output from a transducer of this type, the piezoelectric element is divided into two electrically isolated portions. A feedback circuit is then connected to one of the piezoelectric portions as is disclosed in U.S. Pat. No. 3,815,129. This type of assembly using three terminal connections, one to the conductive substrate and one each to the two portions of the piezoelectric element, will produce a much greater sound out put than the conventional manner of attaching a terminal merely to the conductive substrate and one to the piezoelectric element. A representative type of circuit to produce the desired sound is also disclosed in said U.S. Pat. No. 3,815,129, the contents of which are incorporated by reference herein.

In the past, the units which mount an electrically connected transducer of the type described, have a permanent, non-cyclable means of attaching or mounting the transducer to the unit, either by means of a solder connection or some sort of cement. Examples of units of this type as disclosed in U.S. Pat. Nos. 4,013,982 and 3,331,970.

It is found to be desirable for both assembly and manufacturing purposes, to mount a transducer of the type described herein in a non-permanent manner. One example of an assembly which accomplishes this general purpose is disclosed in U.S. Pat. No. 3,885,173. This patent discloses an apparatus which includes a gasket and a housing wherein the gasket is made of resilient material having conducting regions. The gasket is then layed upon a printed circuit board and the transducer is mounted thereover. A housing provides the necessary mechanical coupling for pressing the transducer against the gasket to electrically connect the transducer to the printed circuit board.

Although the apparatus disclosed in U.S. Pat. No. 3,885,173 accomplishes its intended purposes, it is expensive in that it uses an elastomeric gasket and it does not lend itself to easy assembly in an ordinary manufacturing production process.

SUMMARY OF THE INVENTION

It is therefore, the principal object of the present invention to provide a connector assembly for holding and electrically connecting a transducer, having piezoelectric element mounted on a conductive substrate to a circuit member, in a manner which is easy to use, manufacture and still provide selective removability.

One means of providing the desired object is a connector assembly comprising a base means mountable on said circuit member; at least two resilient terminals associated with the base means; and cover means removably mountable on said base means for selectively securing said transducer in contact with said terminal. One of the terminals has an end adapted to be electrically connected to the circuit member and the other adapted to electrically and resiliently contact the conductive substrate. The other terminal has one end adapted to be electrically connected to said circuit member and the other end adapted to electrically and resiliently contact said piezoelectric element.

Another connector assembly accomplishing the above object comprises a base means which is mountable on the circuit member including holding means integrally formed therewith removably securing the transducer to the base means. Two terminals are associated with the base means. One terminal has one end adapted to the electrically connected to said circuit member and the other end adapted to electrically contact the conductive substrate. The other terminal has one end adapted to the electrically connected to said circuit member and the other adapted to electrically and resiliently contact said piezoelectric element. The top of the terminals are a distance greater from the circuit member than the distance that the holding means hold the transducer from the circuit member so that the transducer is pressed in resilient contact against the terminals when secured on the base means by said holding means.

Another embodiment of the connector assembly achieving the desired object generally comprises an integrally formed unitary base means mountable on the circuit member. The base means includes holding means made of electrically conductive material which is adapted to contact the conductive substrate and for removably securing the transducers to the base means, first terminal means electrically connected to said holding means and adapted to be electrically connected to said circuit member, and second terminal means electrically isolated from said first terminal means having one portion adapted to the electrically connected to said circuit member and another portion adapted to electrically and resiliently contact said piezoelectric element.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded partially fragmented perspective view of one embodiment of the connector assembly of the present invention;

FIG. 2 is a plan view showing a transducer disc that may be used in association with the connector assembly of the present invention;

FIG. 3 is a side sectional view of the connector assembly shown in FIG. 1 completely mounted on a circuit member;

FIG. 4 is an exploded perspective view of a second embodiment of the connector assembly of the present invention;

FIG. 5 is a side view, partially in section, showing the connector assembly of FIG. 4;

FIG. 6 is an exploded perspective view of a third embodiment of the connector assembly of the present invention; and

FIG. 7 is a side view, partially in section, of the connector assembly of FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The connector assembly of the present invention is intended to work best with a transducer of the type already described, i.e., one that is very thin in profile which lends itself to vibration upon electrical excitation. One example of the type of transducer that can be used is shown in FIG. 2 of the drawings in the form of a circular disc. It is understood, however, any generally thin shaped form could be used and still work in the connector assemblies to be described hereinafter.

Turning to FIG. 2 in greater detail, the transducer, generally designated 10, is seen to include a piezoelectric element 12 which is mounted on a larger substrate 14 made out of conductive material such as brass. If a feedback circuit is desired, the piezoelectric element 12 will have an electrically isolated island 16. The electrical island 16 is then connected to the feedback circuit.

Turn now to FIGS. 1 and 3 in greater detail, one connector assembly of the present invention, generally designated 20, is seen to be connectable to a printed circuit board 22. The printed circuit board has a plurality of mounting holes 24 and terminal holes 26.

The connector assembly 20 includes a base member, generally designated 28, including a housing portion 30 having depending mounting hooks 32 and snap protrusions 34 formed thereon. The mounting hooks are adapted to be snap fit into the mounting holes 24 formed in the printed circuit board 22. This mounting would be preliminary to any soldering operation as will be described in greater detail hereinafter.

The inside of the base member 28 has an upstanding nodal circular support 36 on which the transducer 10 is adapted to rest. It is to be noted that the support 36 has a knife-like edge to approximate a line contact only on the bottom of the transducer 10.

A plurality of vertical positioning ribs 38 are formed on the interior wall of the housing 30. These ribs 38 will locate the transducer so that it will not touch the interior housing wall which might dampen any vibration which is produced by the transducer 10.

The interior of the base member housing 30 includes three terminal cavities 40, 42 and 44 which are adapted to mount three resilient terminals 46, 48 and 50, respectively therein. Each terminal 46, 48 and 50 has a locking tang 52 formed thereon to abut against the shoulder 54 formed in the cavities 40, 42 and 44 to lock the terminals therein. It is to be noted that the terminals when initially mounted in the respective terminal cavities will extend above the height of the circular support 36 and will be resiliently pressed downwardly with the downward force provided on the transducer 10.

In order to provide the downward force and, therefore, the electrical connection with the terminals, a cover, generally designated 56, is provided. The cover 56 is in the form of an open ended cylindrical housing 58 having an opening 60 in its top and a plurality of snap latches 62 which are adapted to cooperate with the snap protrusions 34 formed on the base housing 30.

The inside of the cover housing 56 has a depending circular nodal ridge 64 which is in alignment with the circular support ridge 36 formed in the base member 28. The depending ridge 64 divides the cover housing 58 into a central resonating chamber 66 surrounded by an annular chamber 68.

It is important to note that the diameter of the circular support ridge 36 and the depending ridge 64 is designed to be substantially the same as the nodal diameter of the transducer 10. This nodal point or diameter is the place where the transducer 10 would naturally vibrate. Therefore, if the transducer is held at this point, the least amount of dampening effect will result to produce the greatest amount of vibration and sound. In addition, for the purposes of preventing dampening, the terminals 46, 48 and 50 should be resilient so that a greater unimpeded vibration is generated. To amplify the sound, the resonating chamber 66 is provided while still remaining in contact with the transducer 10. However, even though all of these features would be necessary to produce the optimum amount of sound, it is not necessary to provide these features if an application of a lesser sound output is desired.

In use, the entire assembly 20 can be preassembled prior to any manufacturing operation. First, the terminals 46, 48 and 50 are mounted in their respective terminal cavities 40, 42 and 44 respectively. Then, the transducer 10 is placed with the piezoelectric element 10 facing downward onto the resilient terminals 46, 48 and 50 and the circular support ridge 46. The cover 56 is then snap fit onto the base member 28 so that the respective snap protrusions 34 cooperate with the respective snap latches 62.

When the assembly is completed, it is placed on the printed circuit board 22 initially so that the mounting hooks 32 are received in their respective holes 24. The printed circuit board 22 is then wave soldered to produce solder joints 70 to electrically connect circuitry (not shown) on the printed circuit board 22 with the transducer 10.

If, for any reason, it is desired to replace the transducer 10, the cover 56 is removed by unlatching the snap latches 62 from the snap protrusions 34. This operation can be performed many times.

Turning now to FIGS. 4 and 5 and in greater detail, another embodiment of a connector assembly, generally designated 80, is shown mountable to a printed circuit board 82. The printed circuit board 82 has a plurality of mounting holes 84 and terminal holes 86 for purposes which will become more apparent hereinafter.

The connector assembly 80 is seen to generally include a base member 88 having two mounting hooks 80 which are adapted to be received through the mounting holes 84. Four upstanding support members 92 extend from the base member 88 which provide a platform for the transducer 10 when it is mounted on the base member 88. Two upstanding clamp members 94 are provided to clamp the transducer 10 in the base member 88. The combination of the four supports 92 and the two clamp members 94 comprise a holding means for the transducer 10.

The base member 88 has three terminal cavities 96, 98 and 100 which are adapted to receive three terminals 102, 104 and 106, respectively therein. Each of the terminals 102, 104 and 106 has a locking tang 108 which is adapted to engage a shoulder 110 formed in each of the cavities 96, 98 and 100. In this manner each terminal

102, 104 and 106 is locked within their respective cavity.

It is to be noted that the terminals 102, 104 and 106 are resilient and, when they are in the base member 88 before the mounting transducer 10, extend a height greater than the height of the four upstanding supports 92. When the transducer is held in the holding means, the terminals are resiliently pressed downwardly.

In order to facilitate insertion and removal of the transducer 10 a pair of cut outs 112 are provided on opposite sides of the transducer 10 which are alignable with each clamp member 94.

In use, the terminals 102, 104 and 106 are mounted in their respective terminal cavities 96, 98 and 100. At the base member 88 is then mounted on the printed circuit board 82 by inserting the mounting hooks 90 into the respective mounting holes 84 in the printed circuit board. When this occurs, the bottom portion of the terminals 102, 104 and 106 extend below the surface of the printed circuit board 82.

The printed circuit board then can be wave soldered producing a permanent solder joint 114 with each of the terminals 102, 104 and 106. The transducer 10 is then mounted on the base member by aligning the cut outs 112 with the clamping members 94 and pressing downwardly.

It is understood that it is not necessary to have a three terminal feedback system. A noise can be produced by using the conventional two terminal system.

Turning now to FIGS. 6 and 7 in greater detail, another connector assembly, generally designated 120, falling within the scope of the invention is shown in association with a printed circuit board, generally designated 122. The printed circuit board has three apertures 124, 126 and 128 formed therein for purposes which will become more apparent hereinafter.

The connector assembly 120 is seen to include an integrally formed unitary base member, generally designated 129, made of electrically conductive material. The base member 129 can be stamped and formed to the structure which is described in greater detail hereinafter.

The base member 129 has four upstanding support surfaces 130 and two end panels 131 formed therefrom. Each of the end panels 131 has a pair of top support tabs. The support surfaces 130 and the support tabs 132 comprise a holding means to hold the transducer 10 in the base member 129.

A pair of depending terminal tabs 134 and 136 are struck from the base member 129 and bent downwardly in an area below the end panels 131. The terminal tabs 134 and 136 are each adapted to be received in the apertures 124 and 126 respectively. Each of the terminal tabs 134 and 136 have an outward bend 137 formed therein to provide a preliminary mounting means for the base member 129 in the printed circuit board 122 when received in the apertures 124 and 126. Because the entire base member is unitary and made of conductive material, the terminal tabs 134 and 136 are electrically connected to the holding means which comprise the support surface 130 and the support tabs 132.

The base member 129 also has a frangible portion 138 formed therewith. The frangible portion has a depending tab 140 which is adapted to be received in the printed circuit board aperture 128. Formed on top of the frangible portion 138 is a resilient contact 142 which is adapted to contact the piezoelectric element 12.

For reasons which will become more apparent hereinafter, it is necessary that the frangible portion be electrically isolated from the remainder of the base member 129. To this end there is provided a preformed break-away line 144 for breaking the frangible portion 138 from the base member 129.

In use, the base member 129 which is an integral unitary form is mounted on the printed circuit board 122 so that terminal tabs 134 and 136 are received through apertures 124 and 126 and depending tab 140 is received in aperture 129. The bends 137 in the terminal tabs 134 and 136 will prevent the base member 129 from dislodging from the printed circuit board 122. The printed circuit board 122 is then wave soldered resulting in three solder joints 146. The frangible portion 138 is then broken away at the break-away line 144 from the remainder of the base member 129 to make it electrically isolated therefrom.

The conductive substrate 14 of the transducer 10 is mounted in the holding means between the respective support surfaces 130 and support tabs 132. In this configuration, the holding means contact the conductive substrate 14 of the transducer 10 which is electrically connected to the terminal tabs 134 and 136. The frangible portion 138 is in contact with the piezoelectric element 12. In this manner, an extremely low cost transducer connector assembly is provided.

We claim:

1. A connector assembly for supporting a piezoelectric transducer disc in a position generally parallel to and spaced above a surface of a printed circuit board, said connector assembly comprising:

a unitary formed conductive body having

a base structure;

first tab means extending downwardly from said base structure for connection to the printed circuit board and for positioning said base structure adjacent said printed circuit board surface;

a plurality of disc holding means extending upwardly from said base structure engageable with the periphery of the disc at spaced locations around the disc periphery for releasably supporting the disc above the base means and for electrically contacting the disc periphery;

a contact supporting portion;

additional tab means extending downwardly from said contact supporting portion for connection to the printed circuit board and for positioning said contact supporting portion adjacent said printed circuit board surface;

a resilient contact extending upwardly from said contact supporting portion and adapted to electrically and resiliently engage said disc at a region spaced inwardly from the disc periphery; and

a frangible portion interconnecting said base structure and said contact supporting portion, said frangible portion being separable from said conductive body for electrically isolating said contact supporting portion from said base structure.

2. The connector assembly of claim 1 wherein most of said base structure, said contact supporting portion and all of said tab means are beneath a disc supported by said holding means.

3. The connector assembly of claim 1 wherein two of said holding means are movable toward and away from one another in a plane generally parallel to the printed

circuit board surface for selectively holding or releasing the disc.

4. The connector assembly of claim 1 further comprising a preformed break-away line between said frangible portion and said base structure.

5. The connector assembly of claim 1, said base structure including a pair of support portions generally parallel to one another and each supporting a pair of said holding means at opposite ends of said support portions.

6. The connector assembly of claim 5, said base structure further including tie means extending between said support portions.

7. The connector assembly of claim 6, said first tab means comprising a pair of tabs spaced apart from one another.

8. The connector assembly of claim 7, said pair of tabs each extending from one of said support portions.

9. The connector assembly of claim 5, said frangible portion extending between said support portions, and said contact supporting portion extending from a region of said frangible portion between said support portions.

10. A connector assembly for holding a thin, wafer-like transducer including a piezoelectric element mounted on a first side of a conductive substrate and for making electrical connections between the transducer and a circuit member, said connector assembly comprising:

a unitary, one-piece base member including

transducer supporting structure engageable with the first side of said transducer to support said transducer on the base member,

a pair of spaced apart terminal supporting surfaces facing toward said first side of the transducer and being aligned respectively with the piezoelectric element and the conductive substrate of the transducer, and opening means extending away from said terminal supporting surfaces to the exterior of said base member;

a pair of spaced-apart one-piece, metal resiliently formed terminals mounted in said base member, each terminal including

a first portion abutting one said terminal supporting surface,

a second portion extending in the direction of the transducer initially beyond the transducer supporting structure, and electrical connecting means extending from said first portions through said opening means for connection to the circuit member; and

holding means engageable with the transducer supporting structure for holding the transducer against the transducer supporting structure and for resiliently compressing said terminals between the transducer and said terminal supporting surfaces.

11. The connector assembly of claim 10 wherein said transducer supporting structure comprises a circular support corresponding with a nodal region of the transducer and wherein said holding means comprises a cover engageable with said base member and having a circular ridge engageable with a second side of the transducer opposite said circular support.

12. The connector assembly of claim 11 further comprising snap latch means defined on said cover and base member for releaseably securing said cover to said base member.

13. The connector assembly claim 10 wherein said transducer supporting structure comprises a plurality of upstanding support members defining a platform for said first side of the transducer, and wherein said holding means comprises a plurality of clamp members defined by said base member and engageable with edge regions of the transducer.

14. The connector assembly of claim 10 wherein said opening means comprises a pair of terminal receiving cavities, and said electrical conducting means comprises integral segments of said terminals extending to the exterior of said base member.

15. A connector assembly for mounting a thin, wafer-like transducer on a circuit board member and for electrically interconnecting the transducer and the circuit board member, said connector assembly comprising:

a base member including

depending mounting elements engageable with the circuit board member for attaching said base member to the circuit board member,

transducer supporting structure for engaging a first surface of the transducer,

a pair of terminal receiving cavities extending in the direction of said mounting elements to the exterior of said base member, and

a terminal support surface adjacent each said terminal receiving cavity, said support surfaces facing toward said first surface of the transducer;

a one-piece conductive terminal received in each said terminal receiving cavity and including

a resiliently formed portion initially extending from said terminal support surface beyond said transducer supporting structure which is adapted to be resiliently compressed between the transducer and said terminal support surface when the transducer is held against the transducer supporting structure, and

an electrical connecting portion extending through the corresponding terminal receiving cavity to the exterior of said base member and adapted to electrically contact the circuit board member; and

releaseable holding means selectively engageable with said transducer for releaseably holding said transducer against said transducer supporting structure.

16. The connector assembly of claim 15 wherein said transducer supporting structure comprises a circular support corresponding with a nodal region of the transducer and wherein said holding means comprises a cover engageable with said base member and having a circular ridge engageable with the second side of the transducer opposite said circular support.

17. The connector assembly of claim 15 wherein said transducer supporting structure comprises a plurality of upstanding support members defining a platform for said first side of the transducer, and wherein said holding means comprises a plurality of clamp members defined by said base member and engageable with edge regions of the transducer.

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